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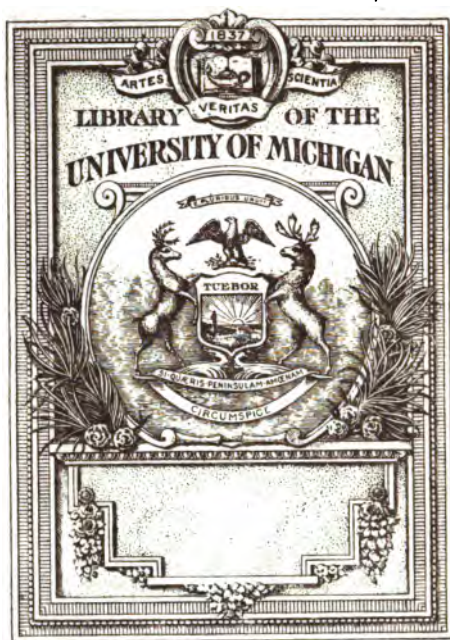
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J. C. Russell
THIRD ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF PENNSYLVANIA.

= Geol. Survey (1st, 1836-1841)

BY HENRY D. ROGERS, STATE GEOLOGIST.

READ IN SENATE, FEB. 19, 1839.

HARRISBURG:
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....
1839.

SECRETARY'S OFFICE,

Harrisburg, February 19, 1839.

SIR:—I have received the third annual report of the State Geologist, which is herewith transmitted, in compliance with the acts of Assembly on the subject of a Geological survey of the state.

And am, respectfully,

FR. R. SHUNK,

Secretary of the Commonwealth.

HON. CHARLES B. PENROSE,

Speaker of the Senate.



REPORT.

To the Secretary of the Commonwealth of Pennsylvania :

SIR:—I beg leave to transmit through you to the Legislature, the following report of the operations of the Geological survey of the State during the past year.

In accordance with the views set forth and adopted in my two preceding annual reports, I shall confine myself to an account of the progress which has been made in the field explorations and other work of the survey, and to a general description of the parts of the State which have recently been under examination, intending to reserve, as heretofore, the principal portion of the details collected, with a view of submitting them to the public in a more useful and intelligible shape, in a final and comprehensive description of our mineral resources at the close of the investigation.

The requisite time will thus be gained for completing the maps and the numerous illustrative drawings, some of which are now in hand and will be found indispensable to a full and clear understanding of our Geology. Until this species of illustration, so indispensable to a correct idea of the innumerable local details involved in a complete delineation of our formations; can be presented, the most copious descriptions must fail to impart more than a very inadequate and erroneous notion of many intricate and curious features connected with the distribution of our strata, and the situation and range of their contained mineral deposits. Between the season, when the specimens of ores and other materials collected for analysis are gathered in, and the period for presenting the annual report on the survey, the interval is too brief for completing the chemical examinations which are so necessary to a thorough knowledge of their economical value; and this constitutes another reason for omitting numerous minute local references which would possess but half their usefulness if unaccompanied by a statement of the chemical composition of the various substances met with.

CHAPTER I.

OF THE SECTIONS OF THE STATE WHICH HAVE BEEN EXPLORED
DURING THE PAST YEAR.

With a view to expedite the Geological survey as far as compatible with accuracy, in the determinations, and for the purpose of giving to all districts of the State alike, the advantages of an early examination, the last Legislature authorized an increase in the number of assistants in the corps, adding six assistants, and a draughtsman. But little delay has been incurred in procuring individuals of requisite talents to fill the places thus created, and when the spring was sufficiently opened to permit a renewal of our investigations in the field, the corps of assistants was complete, with the exception of two whose services were secured after the lapse of a few weeks.

It now embraces in all, nine Geological assistants, four of whom, namely, Messrs. HARVEY B. HOLL, ALEXANDER M'KINLEY, CHARLES B. TREGO and JAMES D. WHELPLEY, hold their places under former acts; the other five, namely, JAMES T. HODGE, Dr. JACKSON, JOHN C. M'KINNEY, PETER W. SHAEFFER and TOWNSEND WARD, having been appointed under the recent law. There are moreover two chemical assistants, Dr. ROBERT E. ROGERS, appointed under the first act, and MARTIN BOYE, under the late one.

Greatly aided in my plans for a speedy and general exploration of the State by this important addition to the number of my assistants, I proceeded without delay, to re-organize the operations of the survey so as to extend our investigations to various districts not before examined, and to explore in detail a much larger territory than could have been submitted to observation with the limited number of assistants previously employed, and what must be considered as of equal consequence, to impart to the developments which are made, a proportionably increased degree of minuteness and accuracy.

Previously, our researches had been chiefly confined to one district of the State, namely, that which is included between the South mountain, and the foot of the Allegheny mountain, and between the Susquehanna and the Delaware rivers, being directed more particularly to the minute investigation of the several anthracite coal fields.

Encouraged, however, by the additional aid provided by the Legislature, I have distributed the corps, as far as practicable, over the whole State, assigning a different district to each person, or to two together as the extent and intricacy of the region, or the limited number of the assistants suggested. Accordingly, the whole surface to be explored, was divided into six districts, naturally separated by tolerably well marked boundaries, both Geographical and Geological.

The *first* of these divisions includes all the counties lying south and east of the Kittatinny valley, embracing Philadelphia county, Delaware, Bucks, Montgomery, Chester, Lancaster, York, Adams, and parts of Lehigh, Berks and Dauphin counties. Mr. Holl has assisted in the investigation of part of this region, lying between the Schuylkill and Susquehanna rivers, while Mr. Boye aided me, during a part of the season, in the country lying between the Schuylkill and the Delaware. The counties of York and Adams were not embraced in the operations of the season, nor was it in our power to traverse more than about one half of the other counties enumerated.

The *second* district comprises the north-eastern part of the Appalachian region of the State, or all that part of our territory which is embraced between the north-western base of the South mountain and the south-eastern base of the Allegheny mountain, and between the Delaware and Susquehanna rivers, terminating on the latter at Muncey creek. This district, the seat of the operations of the previous year, had already received a considerable share of investigation, though the amount of time devoted to it had been insufficient for that detailed and thorough examination of the several anthracite basins which these obviously require, both from their pre-eminent public importance and from the minute and intricate relations of their numerous beds of coal. It was deemed advisable, therefore, to continue the work of developing these coal basins, with as large an amount of assistance as the claims of the several other quarters of the State would justify I accordingly devolved the important task of exploring the south-eastern and middle coal regions to Mr. Whelpley, aided by Mr. Shaeffer, who were facilitated in executing numerous detailed measurements by competent surveyors, whose services were procured for the occasion.

It is conceived, however, that at least another year will be required before a multitude of local points of structure, still obscurely under-

stood and upon a precise knowledge of which the successful tracing of the coal must much depend, can satisfactorily be made known.

The south-western half of the Appalachian region, or that included between the Susquehanna river and the state line of Maryland, and between the South mountain and the Allegheny mountain, constitutes our *third* Geological sub-division of the State, and presents in its complicated topography, and in the numerous rich deposits of iron ore distributed over many of its curiously constructed valleys, a wide field for investigation, requiring close and patient research. The assistants who have been aiding me in the investigation of this difficult region, are Mr. M'Kinley and Dr. Jackson, who, during the season, have explored in detail nearly all of that part of the district which includes portions of the counties of Union, Lycoming and Centre.

That important half of the State which is bounded on the south-east by the main ridge of the Allegheny, on the north by the State of New York, and on the west by Ohio, embracing nearly all the bituminous coal fields of Pennsylvania in a series of closely connected basins, was also sub-divided into three districts. These, however, are less distinctly separated by their Geological structure and resources than the division before traced. One of the districts alluded to, which I shall call the *fourth* in the State, takes in the whole country between the base of the Allegheny mountain on the south-east and Chesnut ridge or west Laurel Hill on the north-west, extending from the Maryland state line to the Bellefonte and Brookville road. In the arduous task of exploring this very interesting, but wild and forest country, I devolved the details of the examinations upon Mr. Trego, who was aided by Mr. Ward. A large portion of the southern half of this region has been explored, probably with as much minuteness as the wild and wooded character of the surface would permit, while other sections, especially the northern half, will demand a considerable amount of additional research, before a sufficiently clear view of the situation and extent of the mineral wealth of the district can be acquired.

The *fifth* district comprises nearly all the counties lying west of Chesnut ridge, and of a line prolonged north from its northern extremity along the eastern county line of Armstrong and Venango, and thence through Warren to the state line of New York. In order to secure as speedily as possible a developement of this part of our

State so highly endowed in its Geological resources, I divided it for the season into two sections, assigning to Mr. M'Kinney the duty of aiding me in exploring the southern half and to Mr. Hodge the same duty in regard to the northern portion. In that portion of the district lying south of the Allegheny and Ohio rivers, about one half of the data necessary to a thorough understanding of its economical geology or useful mineral resources have been collected, while, throughout the rest of this extensive western region, a rather less degree of progress has been made, in consequence of my not procuring the services of Mr. Hodge until the two first months of the season had elapsed.

The *sixth* and last division of the State, includes all those parts of Luzerne, Lycoming and Centre counties, which lie north or north-west of the base of the Allegheny mountain; also the northern two-thirds of Clearfield and Jefferson, the eastern half of Warren, and the whole surface of M'Kean, Potter, Tioga and Bradford counties.

The five large sections of the State previously enumerated, engrossed the attention of all the assistants in the survey and a very large share of my own time, the remaining portion of which was spent in parts of the region last designated. It was not practicable, therefore, to undertake during the season a regular survey of the extensive counties in the northern part of the State, which, throughout more than four-fifths of its surface, is an unbroken wilderness, requiring for the examination of its little known, but inexhaustible resources, a party specially equipped with tents and other accommodations for subsisting in and traversing its dense forests. The extent of my observations in this quarter of the State, has consisted in a personal reconnoissance made during a few weeks in parts of Warren, M'Kean, Jefferson, Clearfield and Centre counties, with a view of ascertaining the best mode of overcoming the peculiar difficulties which the wilderness character of the region presents to accurate Geological researches, and of planning for the future seasons of the survey a systematic exploration of its well-stored coal fields. Enough was discovered of the Geological structure and peculiar topography of this portion of country, to enable me to determine the most eligible method of conducting a detailed examination, and to authorize the conviction, that the real extent and position of its mineral wealth can be satisfactorily ascertained, within a period as brief as will be wanted for the survey of the other districts of the State.

Many reasons suggested the propriety of distributing the corps of assistants in the manner above designated. It was desirable to afford to every part of the commonwealth, as far as practicable, the advantages of an early survey of its own peculiar mineral resources, and a simultaneous exploration of several districts is obviously the only mode by which, in a limited number of years, the requisite degree of precision can be attained. Each district has a more or less different class of deposits disposed in a special order, not to be witnessed elsewhere; it has also a different topography, which when adequately studied affords oftentimes a valuable clue in tracing its mineral deposits; while, on the one hand, it has its peculiar difficulties that demand much local knowledge to surmount, and on the other, features calculated to lead to useful discoveries, if familiarly understood. By allotting, therefore, a particular range of country, as far as possible, to each individual in the corps, and restricting his explorations to that alone, until he shall have mastered its geology and mineral resources in all their local details, an important economy of time is effected, and increased accuracy in the results is insured.

Having adopted this system, my own duties have consisted in visiting every district several times in the season, in regular rotation, and in personally superintending the explorations as they proceeded. This plan tends to remove the difficulties in the investigation as they arise, by contributing the experience and information gained in the other quarters of the State to any particular case to which they may apply. It enables me also, without loss of time, to institute when necessary a fresh series of measurements, or if the work be much retarded by local intricacies, such as occasionally occur, to concentrate an increased number of assistants to the point. While thus superintending and directing these investigations, I deem it my duty to review in person every portion of the field explored, which possesses the least share of practical or scientific interest; so as to be able, while checking the results of the assistants, to satisfy myself by personal observation of the facts and conclusions with which they continually furnish me.

CHAPTER II.

A GENERAL SKETCH OF THE OPERATIONS OF THE SURVEY IN THE DISTRICT'S SOUTH-EAST OF THE ALLEGHENY MOUNTAIN.

SECTION 1.

Of the first or south-eastern district, embracing the country lying to the south-east of the Kittatinny valley.

The south-eastern or first district in the foregoing Geological division of the State, comprehends all the region which lies to the south-east of the great limestone belt which ranges through the Kittatinny or Cumberland valley, or in other words, it is bounded on the north-west by the north-western base of the chain of hills called the South mountain. The rocks which appertain to this populous and highly favored section of our State are of several descriptions, as follows: each presenting several varieties and embracing minerals of more or less utility and interest. First, various species of the so called primary stratified rocks, as gneiss, mica slate, talc slate, crystalline limestone or marble, serpentine, &c.

Secondly, unstratified crystalline rocks of undoubted igneous origin, as granite and sienite, both of them usually in thin veins, and also greenstone, basalt and other species of trap rock penetrating and overlapping the primary and secondary strata in dykes and ridges of considerable magnitude.

Thirdly, rocks of sedimentary origin of the class called secondary. Some of these claim identity with the lower formations of the great Appalachian series of strata, more fully developed throughout the rest of our State, to the north and west of the South mountain, while others belonging to deposits of a somewhat more modern era, their materials having been brought together after the strata, embracing all our coal seams, were upheaved to form part of the dry land. Of the former are the sandstones designated as formation No. I, of our Appalachian series; these compose a considerable portion of the rocks of the South mountain. Next the limestones or formation II, of the same series; these occupy nearly all the central tracts of Lancaster county. Lastly, the slats of formation III, identical with the slate

rocks of the north-west side of the Kittatinny valley, but confined in this district to a few small valleys subordinate to the chain of hills in that part of the range which is east of the Schuylkill river.

The other group of secondary rocks in this district composes red shales, and red and grey sandstones, and several varieties of conglomerate, all belonging to one series of deposits of a date posterior to the coal, and occupying a long and irregular trough extending across the State from Maryland to New Jersey, through the counties of Adams, York, Dauphin, Lebanon, Lancaster, Berks, Chester, Montgomery and Bucks. To these rocks I propose to give the name (for convenience sake) of *middle secondary strata*, in contradistinction to the Appalachian formations on the one hand, which are unequivocally our lowest secondary formations, and on the other hand to the green sand deposits of New Jersey, Delaware and some of the southern states which constitute the uppermost secondary strata of our country.

The primary rocks of Pennsylvania, which are confined exclusively to this south-eastern division of the State, are spread over a very limited area, probably not exceeding one-fifth of the surface of the district. They extend in two distinct and narrow belts from the Delaware river to the Maryland state line, occurring in the south-eastern tract in one continuous range, but appearing in the north-western one only in insulated patches in the chain of hills called the South Mountain.

The more southern of these belts commences at a spot in New Jersey about six miles north-east of Trenton, where the primary rocks emerge from beneath the overlapping red strata of the middle secondary series. Commencing in a narrow point, they gradually expand in width as they range south-westward along the southern border of the State and the adjacent parts of Delaware and Maryland. The south-eastern margin of these primary rocks crosses the Delaware river a little below the bridge at Trenton, and passes by Bristol, Philadelphia, Chester and Wilmington, keeping parallel with the general course of the river, separated from it by a narrow fringe of overlapping diluvial and alluvial deposits of rarely more than a single mile in width. The northern margin, commencing at the same point in New Jersey, crosses the Delaware about a mile and a half above Trenton, and stretches in a somewhat undulating line south of west so as to meet the Schuylkill about two miles below Norristown and

the Susquehanna at Turkey Hill, below Columbia. Between the Susquehanna and the Maryland state line, its course is rather more south-westerly.

The long wedge-shaped tract here delineated, has not as yet been traversed with a view to that minute and systematic examination which it demands. It offers for Geological exploration many useful and interesting materials, among which are belts of gneiss and sienitic trap rock for building, with a formation of crystalline marble in much request for the higher purposes of architecture, besides many exposures of serpentine beds of whetstone and localities of valuable and curious minerals, such as the ores of iron, manganese and chrome. The investigation of the Geology of this belt of country and its mineral contents, will form a part of the business of the survey during the approaching season. The primary rocks of the South mountain show themselves principally in the part of the chain which lies between the Delaware and Schuylkill rivers. They are largely developed throughout all that portion of the same range of hills which crosses New Jersey and New York under the name of the Highlands, but they gradually disappear in going south-westward after we enter Pennsylvania, especially as we approach the Schuylkill.

Between the two above mentioned rivers, the South mountains contain both the primary rocks and the lowermost formations of our lower secondary or Appalachian series, or in other words, the sandstone which I have designated in my last annual report as formation No. I, the limestone, formation II, and a little of the slate, formation III; west of the Schuylkill, there is an insulated tract of primary rocks occupying an area of about nine miles in length by two and a half in width, commencing at a point about seven miles west of Reading and ranging along the southern side of Millbough hill, through a small part of Berks and the adjacent corners of Lancaster and Lebanon.

There are a few other very limited patches of the primary rocks, confined generally to the summits of the sandstone ridges through which they seem to have been protruded by the agency of those subterranean forces of elevation, which have lifted up those hills and tilted their strata into the inclined attitudes in which we behold them. Some of these occur in the chain between Allentown and Reading. That part of the South mountain which lies between Adams and Franklin counties, and which is a prolongation of the Blue ridge of

Virginia, embraces a far larger proportion of primary rocks, but its Geology and Mineralogy have not yet been examined; the exploration of those counties in the district, which lie south-west of the Susquehanna, having been unavoidably deferred until the coming season.

Iron ores in the primary rocks of the South mountain.

Crytalline magnetic iron ore accompanies the gneiss rocks of the South mountains in our State in several places, though the veins are much less frequent and extensive than in the same formation in New Jersey. At Durham, on the Delaware, it exists in considerable quantity, to all appearance in the form of regular veins of injection, but these mines have not been wrought for many years.

At Mount Pleasant, in Colebrookdale township, Berks county, the ore is extensively excavated. It would appear to lie in beds, or rather in regular veins, and to be in truth, the magnetic ore of igneous origin, in a rotten and decomposed condition.

Between the northern margin of the southern tract of primary rocks, and the Kittatinny valley, nearly the whole surface, with the exception of limited patches of primary strata in the South mountains, comprehending most of the hills of that chain, and the wide plains spreading southwards from them, consists of the two great formations at the bottom of our lower secondary series and the overlying red rocks of the middle secondary group.

SANDSTONE FORMATION NO. I.

The white and grey sandstone (formation I,) which is the lowermost of the two former, occurs abundantly in the South mountains from the neighborhood of Allentown to the Schuylkill at Reading. In Northampton and the eastern corner of Lehigh, the sandstone, though occasionally met with on the flanks of the hills, is subordinate in importance to the gneiss and other primary rocks upon which it rests; but in Earl township, Berks county, it forms most of the higher hills. Between the Schuylkill and Susquehanna rivers this rock is largely developed in several ridges; it forms the mass of Millbough hill near Womelsdorf, reposing upon the gneiss rocks that lie to the south and sustaining in its turn the limestone strata of the Kittatinny valley. The relative portions of these three formations are here well exposed. It entirely covers the flanks and the

summit of the ridge called the Welch mountain, in the eastern corner of Lancaster and the adjacent parts of Chester counties. This uplifted belt commences about three and a half miles east of Morgantown, and terminates a little south of New Holland, having a length of about fifteen miles. On the south it lies upon the gneiss, the line of junction between the two rocks following the foot of the ridge, while on the north it is covered by the limestone which overlaps it to the very base of the hill. West of Churchtown, in Lancaster county, the sandstone has been brought to the surface, through the overlying limestone strata, in a little insulated hill, about one mile in length, and it forms another very similar low ridge of about the same dimensions near Neffsville, where its strata dip away in opposite directions from the summit of the hill, forming thus an anticlinal axis, as it is termed, along its centre. Again, in the western part of Lancaster county, this sandstone has been protruded through the limestone in the form of a bold ridge of hills which crosses the Susquehanna between the towns of Columbia and Marietta. The most eastern exposure of the rock in this tract, is near the village of Hempfield, three and a half miles from Lancaster, from whence the northern border of the stratum extends northward for about a mile to the White Horse tavern, and thence sweeps westward and southwestward, following up the valley of Kauffman's run, from which it stretches nearly westward to the mouth of the Chickasalongo creek. Its southern edge passes the village of Mount Pleasant, whence it extends with but little undulation to the Susquehanna, which it crosses not far above the bridge at Columbia. A little below that town, and also at Marietta, the sandstone beds are seen alternating with the lower strata of the next superior rock, the limestone (formation II,) exhibiting a southern dip at the former place and a northern one at the latter. Some of these upper alternating beds of the sandstone, graduate into a material which is in some places nearly a pure slate; in the bold exposure of this formation on the Susquehanna, we behold abundant evidences of the change which this rock has undergone in its texture from the heating action of the veins of quartz which have been injected into it from below. Some of these veins of quartz bear a marked analogy to those which, in the southern states, contain the gold, a resemblance which has excited hopes from time to time that this enticing metal might really be present in some quantity within our State. But a careful analysis of the most promising specimens, not only from the locality on the Susquehanna, but

from several others in York, Lancaster, Chester and Berks counties, has assured me that any dreams of riches from such source must prove wholly delusive, no appreciable quantity of the metal having been hitherto detected. The copper mine ridge consists throughout the chief part of its length of this sandstone formation, and some of the hills bordering the western part of the limestone valley of Chester county on the north, would appear to contain the same rock. But this belt of country near the southern primary range has not yet been minutely traced.

Iron Ore.

This lowermost stratum of our secondary series is occasionally the repository of very valuable collections of iron ore, one very extensive and rich deposit of which occurs upon it on Chesnut hill, about four miles from Columbia. It lies in a basin-shaped depression in the rock and is sometimes confusedly mixed with sand, clay and steatitic matter, and sometimes lies surrounded by a less proportion of foreign matter in nearly horizontal beds. Large bodies of similar ore, technically termed the brown argillaceous iron ore, are associated with this sandstone or appear at least to have been derived from it, in several places near the South mountain chain, especially along the southern side of the Kittatinny valley, in Lehigh, Northampton and Lebanon counties. A little iron ore has been found in it in the Welsh mountain near the turnpike, but not in sufficient quantity to be valuable.

LIMESTONE FORMATION MO. II.

Resting upon the sandstone just described, the next formation in the ascending order is the valuable blue limestone stratum which occupies nearly one-half of the entire area of Lancaster county. This is the same rock with that which was described in my last annual report, as extending along the southern side of the Kittatinny valley, throughout its whole length, and which is there designated as formation II, in our Appalachian system of strata. It covers a large and important tract in the district south-east of the Kittatinny valley, spreading over the broad and fertile plain which extends in an east and west direction through the central townships of Lancaster and York counties. The eastern limit of this great expanse of limestone is about three miles east of Morgantown in the southern corner of Berks county. Its south-eastern margin extends from thence along

the northern base of the Welch mountain, which it follows to its western end, near New Holland, in contact with its white sandstone. There the limestone doubles round the end of the ridge and spreads eastward through the southern half of Salisbury township into Chester county. From Chester county, the southern limit of this rock follows, first the northern base of the Mine hill as far as Strasburg township, after which it courses along the foot of a chain of low hills in the same westward prolongation to the Conestoga creek; it then descends along the valley of this stream as far as the north-eastern foot of Turkey hill, around the various spurs of which it winds until it reaches the Susquehanna river at the mouth of Wister's run. Throughout this course the limestone lies in contact either with the sandstone (formation I;) or with the gneiss or talc slate rocks of the primary class. The northern margin of the limestone starting at the same point near Morgantown, ranges westward across Lancaster county in a somewhat undulating line to the Susquehanna, which it crosses immediately above the village of Bainbridge. Lying to the north of this large expanse of limestone, and separated from it by a long tongue, as it were, of the red rocks of the middle secondary series, are two other valleys of the limestone, the eastern one containing the waters of the Cocalico creek, and the western one the Moravian towns of Litiz and Manheim. The limestone along its whole northern limit, between Morgantown and Bainbridge disappears beneath the overlapping strata of red sandstone of the middle secondary series, the beds of which may be seen resting upon it in an *unconformable* position, having generally a dip toward the north at an angle of from fifteen to twenty-five degrees. There is evidence that these newer or middle secondary rocks once spread themselves southward over the limestone much more extensively than at present, the destructive agency of a heavy current of waters having removed a large tract of the uppermost formation. To the same action we may refer the peculiar bench or terrace which the overlying red sandstone uniformly presents along its margin rising from thirty to forty feet above the plain occupied by the limestone. The removal of the upper rocks at a point about four miles west of Manheim has laid bare a small and narrow patch of limestone upon Chickasalungo creek, not much exceeding half a mile in length.

This valuable formation likewise shows itself in a few confined valleys subordinate to the South mountain, in the neighborhood of the Delaware and Lehigh rivers; one of these tracts ascends the val-

ley of Durham creek from its mouth as far as Springtown, the calcareous rocks showing themselves even to the west of the Hellertown road; another belt of it pursues the valley of Saucon creek to its very head, almost two miles north-east of Shimersville. A narrow strip of the same rock is seen along the Little Saucon creek for about three miles above its mouth. Further towards the south-west the limestone is less abundant, being seen only in small and detached exposures. It occurs thus in several localities in Upper Milford township, Lehigh county, and in Hereford township, Berks county, as far as the point where the chain of hills divides. The valley here formed, constitutes parts of Oley township, which consists of the limestone in the eastern and southern part, and of the overlying slate (formation III.) in the northern and western part. The limestone also occurs at intervals along the northern margin of the red sandstone. In some of these exposures, as in Douglass township, the limestone is seen in immediate contact with the overlying red sandstone, and in several neighborhoods, as for example, at the south base of Neversink hill below Reading, the very singular, coarse, variegated conglomerate which in this part of the State forms the uppermost bed of the middle secondary group, may be seen dipping directly against the highly inclined strata of the limestone.

MIDDLE SECONDARY RED SANDSTONE FORMATION.

We come now to the red sandstone formation which stretches through the central and northern portions of our south-eastern district in a long and irregular tract from New Jersey to Maryland. As a group of rocks, this is one of the most remarkably uniform in respect to its materials and appearance, in our country. It consists of dark reddish brown sandstones, almost invariably argillaceous, of soft crumbly brown shales and coarse conglomerates, frequently of very heterogeneous composition. The prevailing, we might say the almost invariable direction of the dip of these strata is towards the north at angles varying from fifteen to twenty-five degrees. The lower beds, or those which show themselves along the southern edge of the tract, consist most frequently of rather coarse sandstones alternating with red shales, the sandstones being formed of somewhat angular fragments of quartz, felspar and other ingredients of the neighboring primary rocks, cemented by a paste of brown argillaceous matter. The central parts of the formation consists more ex-

clusively of brown shales and brown argillaceous sandstone, while the uppermost beds, occurring along the northern margin of the formation, have frequently the character of coarse conglomerates, made up of pebbles derived from a very great variety of rocks, chiefly those which occur at the base or on the sides of the adjacent hills of the South mountain chain. Where a large proportion of the pebbles are of limestone and the cementing red earth which unites them contains an adequate quantity of the same materials, the rock possesses the character of a marble, being susceptible of a good polish and resembling certain highly variegated breccias.

Of this character are the beds of this rock near the Potomac river, which furnished the columns in the House of Representatives and the Senate chamber of the Capitol at Washington. The same rock occurs in the vicinity of Reading, and at many other places along the same line, crossing our State, and in every respect seems equally well fitted for the purposes to which the so called Potomac marble has been applied. The hardness of some of the pebbles and the consequent difficulty of dressing and polishing this rock, will account for its not having been hitherto wrought as an ornamental marble in our State, but it is possible that by a judicious application of machinery it might be profitably worked.

Though this conglomerate constitutes the uppermost member of the red sandstone group in various places, both in New Jersey and Pennsylvania, there are other neighborhoods, where, for example, near Bainbridge on the Susquehanna, it would seem rather to occupy a position at the base of the series. All these rock of the middle secondary date of which the argillaceous red and brown sandstone is the predominant and characteristic variety, appear from numerous geological indications to have been produced at a period subsequent to the elevation of the lower secondary strata, including the coal deposits. They seem to have originated in a long narrow trough or bay which had its source at least as far south as the central latitudes of Virginia, and which probably opened into the ocean somewhere near the present positions of the Raritan and New York bays.— Their materials give evidence of having been swept into this estuary or great river from the south and south-east, and hence the almost universal dip or inclination of the beds towards the north-west, a feature clearly not produced by any uplifting agency, but assumed originally at the time of their deposition in consequence of the direction or

set of the currents, which laid them down layer after layer. With the exception of one or two fossil fishes found in this formation in New Jersey, I am not aware that any animal organic remains have been hitherto met with in any part of the stratum, and hence it becomes difficult to assign its precise place in the general series of Geological formations. Relics of vegetation are, however, occasionally found, especially under the form of highly compact and bituminous *lignite*, the transverse section of which bears no remote resemblance to some kinds of cannel coal, while the longitudinal section exhibits very distinctly the fibrous structure of the wood whence it has been formed. This lignite occurring sometimes in seams of two or three inches thickness amid dark shales, has been a fertile source of delusion; some persons having been induced, by the hope of finding valuable coal mines, to expend both time and substance in the search. All the Geological facts produced during the survey of this formation, discountenance the notion that it contains any coal. It seems to have originated at too late an epoch for the production of coal, the conditions under which its deposits were swept together being apparently inimical to the accumulation of a sufficient quantity of vegetable matter; the detached fragments of plants which we meet with in the form of lignite, having evidently been loosely drifted into these sediments from the land.

The general limits of the red sandstone formation, as far as regards the region between the Delaware and Susquehanna rivers, are as follows: Its southern margin, crossing the river about a mile and a half above the town of Trenton, runs nearly westward to the Schuylkill, passing about two miles south of Norristown; it there extends by Valley Forge and Kimberton to French creek, the course of which it follows nearly to the county line of Chester. It passes about half a mile to the north of Morgantown, Churchtown and Hinkletown, and goes through Millport to Buchanan's run, where it suddenly folds back and runs towards the north-east, through Ephrata to Reamstown. From the last point it sweeps in a regular curve, first towards the north-west and afterwards the south-west, crossing the turnpike at Middle creek. Reaching Hammer creek it descends along the course of this stream to Erb's mill, where it turns again westward, passing about a mile to the north of Litiz, and reaches in the same course Manheim. Here it goes once more towards the east, which direction it pursues as far as Buchanan's run, where, however, it again turns westward, continuing in that course uninterruptedly to Spring-

field, at which place it makes another short flexure but soon resumes its western range, passing one mile and a half south of Elizabethtown, and thence nearly in a straight line south-westward to Bainbridge on the Susquehanna. From the Delaware river at Trenton to the Warwick mine, near the head waters of French creek, the red sandstone stratum overlaps the gneiss and other rocks of the primary class. From the latter point it ranges in contact with the white sandstone of the Welch mountain, but on entering Berks county and in its course across the whole length of Lancaster county, its southern margin is every where in junction with the limestone. The northern border of this middle secondary formation, beginning at the Delaware near Durham, if traced westward across our district, will be found to pass about one mile south of Springtown and one mile north of Cooperstown to the Hosacock creek, where the road crosses it in Upper Milford township. It then runs a little to the south of Mount Pleasant iron mines, passes Boyerstown, crosses the Perkiomen one mile south of the Black Bear tavern, and meets the Schuylkill about two miles south of the town of Reading. The Potomac marble or calcareous conglomerate occupies several long narrow tracts along the line just traced; one a little below Springtown, another on the Manatawney creek, and a third on the Limekiln creek. It has already been alluded to as occurring on the Schuylkill below Reading. From this latter point, the northern edge of the sandstone stratum extends with a slight undulation in a nearly western direction to the south-western end of Millbough hill, overlapping first the limestone of the Kittatinny valley, then primary rocks, and finally the white sandstone of the hill. From Millbough hill its range is a little south of west, through Sheafferstown, past the Cornwall iron works and thence along the turnpike to Campblestown, from which it takes a nearly straight course to Highspire on the Susquehanna. Between Millbough hill and the Susquehanna, the red sandstone formation lies every where in contact with the limestone of the Kittatinny valley.

TRAP ROCKS.

The red sandstone formation embraces numerous ridges and dykes of trap rock, indeed nearly all of this rock which is contained in our State is confined to the area occupied by that stratum. It occurs principally in the north-eastern half of the tract. The trappean matter brought to the surface in a state of fusion, through the dislocated red

sandstone beds, gives frequent evidence of its having had a heat which has entirely changed the character of the shales and sandstones, which have sometimes the aspect and texture of an over-baked brick or tile. The Conewago hills consist of the trap rock in several varieties, both fine grained and coarsely crystalline.

IRON ORE IN THE RED SANDSTONE FORMATIONS.

There are several places in the red sandstone tract, where iron ore exists in greater or less abundance. The three principal localities between the Susquehanna and Schuylkill, are the Cornwall mine in Lebanon county, Jones' mine about three miles from Morgantown in Berks county, and the Warwick mine six miles north-east of the same place on French creek in Chester county. The Cornwall mine is extensive and yields ore of very considerable richness, which, however, contains a small proportion of copper. The mine near Morgantown, though formerly wrought to some extent, is now of comparatively little value. The ore is mixed with carbonate and silicate of copper, the excavation having originally been undertaken as a copper mine. In the Warwick mine the ore is apparently of good quality, but hard. A mixture of this and the previously mentioned ore is said to yield a very good metal. All the three iron mines here enumerated, occur in the red sandstone, but in the immediate vicinity of dykes of trap rock. The ore is manifestly of igneous origin, much of it being crystalline and magnetic, and appears, like the trap, to have been injected into the sandstone in a melted condition.

This proximity of the ore to that rock, suggests the same practical rule for its discovery which applies to the copper ores throughout our State and New Jersey, namely: that we should seek for its external indications either immediately along the base of the trap ridges or within a short distance from them. Similar iron ore occurs in the district between the Schuylkill and Delaware rivers, in the red sandstone. The principal mine in this region is Fegeley's at Boyers-town, not at present in operation, in the vicinity of which there is another mine (Rhodder's) in which the ore is magnetic. Numerous details regarding the ores and other useful materials connected with the red sandstone tract of the State, are reserved unavoidably for the more ample pages of the final report.

The opportunity will then be embraced for introducing many particulars respecting all the various substances of any economical value

which appertain to the several formations already described, among which are all the iron ores of the South mountain, whether associated with the gneiss rock, the sandstone formation I, or the limestone formation II; also useful building materials, including ornamental marbles, the whetstones of Hereford township in Berks county, and clays for brick making, and whatsoever else may be deemed of practical importance.

SECTION 2.

General sketch of the operations in the second or north-eastern Appalachian district.

The operations of the survey in the north-eastern half of the Appalachian region of the State, have been principally restricted during the past season to our middle and southern anthracite basins; the detailed exploration of which was systematically entered upon in the previous year. Aided in this part of the survey by two of my assistants, who have taken an active part in the examination since its commencement, I have been enabled to carry on, without interruption or change of plan, the investigation of this highly important and intricate region, giving to the work as it advances, such increase of accuracy in its details, as reiterated observations can alone secure in a country possessing its peculiar and complex structure.

For a more full account of the object and the nature of the measurements performed in the course of this investigation, among these several coal basins and their individual seams and strata, I must refer the reader to my second annual report on the survey. I may however state, that our recent researches in this region have been conducted with a view to delineate as accurately as possible, the boundaries of the several coal basins, to ascertain the relative position, and trace the actual range of each of their important beds of coal, and to discover the existence and trace the direction of all important axes of elevation, and all great dislocations by whose agency the strata are displaced from their regular course, and thereby the hopes and labors of the miner too often frustrated.

In order to accomplish these objects, several distinct species of investigation have been resorted to as necessary.

First. The topography of the region has been critically examined, and the essential dependence which exists between even its lesser features and the Geological structure at each place, carefully studied, as necessary to the construction of a *Geological map* of the whole on a large scale, showing the limits of each basin, the position and range of its principal beds, and of the more influential lines of disturbance affecting the strata.

Secondly. The *superficial evidences*, embracing an examination of the external characters and dip of the strata have been systematically collected with a view to show the presence or absence of coal measures, and to identify and trace the several beds.

Thirdly. A series of parallel lines at right angles to the course of the strata, have been *measured and levelled*, in order to ascertain more strictly the boundaries of each basin, and the true situation as far as possible of each coal seam, and to detect any increase or diminution in the breadth and probable depth of the former or in the mutual distances of the latter, and to impart additional precision to the sectional drawings, which are to elucidate these points, by procuring correct outlines of the surface.

When it is understood by what invariable relations the Geographical and Geological structure of our Appalachian region are connected together, the necessity for this first preparatory operation, *the construction of a map*, on which to lay down our results, will become obvious. Of those at present in use, the best are well known to be defective, and for Geological researches, where slight variations in the course and shape of the mountain ridges and axes of elevation are found to correspond with important changes in the position and direction of the strata, they may be considered as wholly useless.

Abstaining from all minute and local details referring to particular mines or individual coal beds, as not suited to an annual report, from which the indispensable illustrations of maps and sectional drawings which will accompany my final report are necessarily excluded, I shall confine my remarks on the present occasion, to a description of the position and range of the several leading anticlinal axes of our great southern and middle coal fields, or what is the same thing, to a rapid specification of the approximate boundaries of the coal measures, in the numerous lesser basins or synclinal troughs into which those axes subdivide the whole anthracite region. The information imparted in the few following pages will tend, I trust, materially to

aid the examinations of those who are aiming to determine the important question of the existence or absence of coal upon their lands, and if closely attended to, may essentially assist the explorer in ascertaining the true limits of the coal, especially in some of the less known basins. If it should deter even a few from the wasteful expenditures, and many ineffectual enterprises for establishing mines in neighborhoods where the position of those axes, and the appearance at the surface of the lower strata, prove, even without assistance from other Geological evidence, that no coal measures can exist, I shall deem it of more general utility, than any thing in the shape of local details that I could offer in the narrow limits of the present brief report.

In the attainment of this object, combining also careful observations of the soil, the dip and character of the rocks, the position and number of the coal beds, and deposits of iron ore, the greater portion of the past season has been occupied. The other portion of our time was employed in the collecting of specimens, the tracing of coal beds, and in more minute observations on the disturbances of the strata, made both on the surface and under ground in numerous tours of inspection, for this purpose, through the mines. In the Beaver Meadow district, two parallel and long lines of levelling have been completed between seven and eight miles apart. One of these measurements was commenced upon the Spring mountain, opposite the town of Beaver Meadow, and carried in a direction north, twenty degrees west, or nearly at right angles to the range of the strata, and made to terminate on Buck ridge six and a half miles distant. The other was commenced upon Buck ridge, opposite the Sugarloaf mountain, and directed south, twenty degrees east, to its termination upon the Spring mountain, near its western extremity.

The coal deposits of the anthracite region admit of a natural and scientific division, into four distinct groups. First in extent, though not at present in importance, we have the great northern basin, extending from a few miles north of Carbondale on the Lackawanna creek to the Knob mountain, where both boundaries of the basin near their south-western junction are broken through by a notch, giving passage to the river Susquehanna. Separated from this basin by the great anticlinal axis of the Wapwallopen hills, by which the rocks of our formations VIII and IX are brought in succession to the surface, we find the eastern or middle anthracite coal field composed

of eight narrow basins, lying contiguous to each other and containing the lower coal beds of the series, one of which is of great size and importance.

Cut off from these last by the deep red shale valleys of the little Schuylkill, Catawissa and other streams, but situated nearly in the same range, we have the coal fields of the Mahanoy and Shamokin, composing our next natural group of basins. And lastly, south of all these and separated only by the high anticlinal axis of Broad mountain, lie the Broad mountain, Mine hill and Pottsville coal basins, the last extending eastwardly to Mauch Chunk and westwardly to the neighborhood of Pinegrove, where it divides into two branches, the northern one, under the name of Wisconisco mountain, extending westwardly several miles beyond the county line of Dauphin and Schuylkill, to Lykens' valley; and the other embraced between the Stony mountain, and a continuation of the Sharp mountain, reaching nearly to the Susquehanna river. From Geological evidences too numerous and striking to be questioned, we infer that all the coal deposits of our anthracite region with their associated rocks, owe their present more or less inclined posture and their limits, to the influence of two grand causes, namely: subterranean elevation and the superficial denuding action of a deluge. Keeping in view the joint operation of these forces, we are enabled to explain as their natural and necessary consequences all those singular positions and complicated disturbances of the coal measures which are so apt to deceive the calculations of the miner, and to elude the researches of those who have adopted their ideas of the structure of all coal basins from the simple forms of the celebrated European coal fields, or the description in elementary books.

As the natural result of the above mentioned cause, we find our anthracite basins connected together into the groups above described. The great stratum of conglomerate rock, formation XII, which is found so remarkably developed in the Sharp and Broad mountains, may be seen underlying every coal field in the region, and indeed points enough of connexion could be traced, which would show the absolute identity of the conglomerate of the Beaver Meadow and Hazleton region, with that of the Mahanoy, and of this again, with that of the Shamokin and Broad mountain troughs, and of the latter with that of the Mine hill and Pottsville basins. Between the conglomerate strata of M'Cauley's mountain and Buck's mountain, and

between those of the Buck's mountain and Wyoming mountain, there is a wide interval, but we have ample Geological evidence to prove, that by the elevation of the lower strata which are here exposed, the conglomerate and its superincumbent coal measures being brought within the influence of denuding currents, have been swept entirely away, leaving no space between to show the original continuity of the deposits of the now insulated basins. Commencing with our eastern or middle district we find seven distinct synclinal basins of the coal measures grouped in close connexion. These may be compared to a like number of long and narrow troughs, lying in contact and parallel with each other. Their range is south sixty-five degrees or seventy degrees east, though particular portions affected by faults or by greater disturbances, present considerable deviations from that direction. These are either separated from each other in every case, by parallel anticlinal ridges of conglomerate rock, or when that has been carried away, from a deeper denudation than usual, they are then divided by narrow valleys of the red shale of our eleventh formation. This latter, is the common structure at the eastern and western extremities of the coal fields, where we find the coal basins terminating abruptly in a prow-shaped form, in those conspicuous mountain spurs or high promontories which stretch eastward and westward from the elevated level of the coal field, into the lower red shale valleys of the Lehigh and Cattawissa. Between the two great axes of the Nesquehoning mountain and the Wapwallopen hills, in both of which the sandstones of our formation IX are brought into view, six lesser anticlinal axes or undulations of the dip are discoverable. The most northerly of these lines of elevation in the strata, crosses the river Lehigh, in the neighborhood of Whitehaven, and passing about west, ten degrees south, terminates in the great bend of the Little mountain, near Cattawissa. Upon the north side of this axis which passes through the central table land which unites the Green mountain with the Buck's ridge, we find the north dipping conglomerates of a small coal basin occupying the summit of Green or Hell Kitchen mountain. In the range of the above basin, but separated by an interval of six or seven miles, we have the Sugar-loaf mountain, lying upon the north dipping beds of this same axis, but containing no coal measures. This latter eminence consists of a mass of the red shale rocks in a nearly level position, capped with a narrow plateau of conglomerate rock, about one hundred feet in thickness. Continuing our range still further westward, we find the

small coal fields of M'Cauley's mountain, crowning an isolate ridge of conglomerate, which has been at one time evidently continuous with the conglomerate stratum of the Sugarloaf and of the Green mountain. On the south dips of the above mentioned axis lies the conglomerate of Buck's mountain. Again, at the junction of the two branches of Black creek, we find evidence of another additional elevation which may be traced eastward through the long summit of Black creek ridge until it is lost in the neighborhood of the Lehigh, and westward through the Raccoon valley, between the south Buck's mountain and the Little Sugarloaf as far as the base of Little mountain. Between these two axes lies the coal basin of Buck's mountain. Our third axis is that of the Council ridge, situated south of the last line, about one and a half miles. This, in its turn, seems to disappear eastward in the vale of Sandy creek, and westward in the red shale valley at the foot of Little mountain. Between this and the former, lies the coal basin of Black creek, a long narrow trough of conglomerate, with a rather shallow deposit of coal measures, commencing at the head waters of Black creek, and terminating in the Little Sugarloaf mountain, which lies between the two branches of the Tomhickon creek.

The fourth in order, and ranging at a like distance south from the last three, is an axis observable near the junction of Hazle creek and Dreck creek, which we shall call the Dreck creek axis. This is continued eastward through the centre of Pissmire ridge to the Lehigh, where it terminates. We may trace its prolongation westward to the very extremity of Green mountain, and thence through the Cattawissa valley, in which it seems to expire. Between the Council ridge axis and that last described, we find the valuable basin of the Hazleton valley extending eastward to the extremity of Pissmire hill, and westward to the end of the Green mountain.

Our fifth axis is the great one in the southern ridge of Pissmire hill, passing near the town of Beaver Meadow. This line of disturbance traverses the valley of Red Shale, called the Indian survey between Spring mountain and the north-eastern prong or spur of Pissmire ridge, while westward, after leaving the coal field, it keeps along the south foot of Green mountain, until lost in the Cattawissa valley. This axis is the southern limit of the Dreck creek basin, a coal deposit, which in depth and breadth is much inferior to that of Hazleton, to which it is precisely similar in the topography towards

its east and west prolongations. In the red shale valley of Quakake creek, we find another axis which flattens out and disappears near the crossing of the Beaver Meadow rail road, through this valley. It is this disturbance which causes the northern dip of the conglomerate in the Spring mountain. Upon this stratum, and upon the southern dipping conglomerate of the Pissmire ridge, lie the coal measures of the Beaver Meadow basin. This is perhaps the largest and most valuable coal field in the group, but is at the same time the most disturbed by *dislocations* and *rolls* of the strata. Commencing at the town of Beaver Meadow, and proceeding westward, we may trace the rise and declension of several axes or wrinkles, caused as it were by the upheaving and by the consequent inward pressure of the two bounding masses of the conglomerate. Such is an outline of the general structure of the eastern middle group.

Our western middle group of basins, including the coal fields of Mahanoy and Shamokin, presents some features of a different character. Owing to their position between the eastern terminations of the two great axes or lines of elevation, those of the Roaring creek and Mahantango valleys, we find the anticlinal disturbances in this group of considerable size and consequence, dividing the extremities of the coal basins and thus causing them to branch off into several small spurs of a synclinal structure, which, however, communicate uninterruptedly with the main valleys or coal basins.

Commencing at the western termination of the great Shamokin coal field where the north and south dipping ranges of the conglomerate unite together, in a high knob between eight and nine miles west of Shamokin gap, we can trace as we go east, a regular basin of coal measures of uncommon width and depth, disturbed only by a single central axis of elevation, which does not bring the lower rocks to the surface. This axis will be found to assume its maximum elevation and importance, uptilting the strata near the Shamokin coal mines, when it soon begins to fall away towards its eastern prolongation, disappearing after a distance of five or six miles. Two or three other similar disturbances, but of less note, begin near Shamokin gap and proceed eastward in a parallel direction, but die away in short distances and are succeeded by others of the same nature. About the crossing of the Sunbury turnpike the valley presents an appearance of remarkable regularity in its topography, if we confine our views to its western portion, but looking towards the east we perceive

the rising of two prominent ridges of nearly equal elevation with those enclosing the whole coal field, and which prove upon examination, to contain the terminations of two great anticlinal axes or lines of elevation dividing the coal field into three branches. The northern and middle of these subordinate basins terminate abruptly in short and high hills. The southern, however, continues with a longer reach along the southern side of the north ridge of the Mahanoy, and thence after being completely divided by a breach or gap runs out in the Head mountain, which is a dividing ridge of the Quakake valley, lying almost in immediate contact with the Spring mountain. In the proximity of these two latter mountains and their anticlinal axes, we behold the natural link connecting our eastern and western sets of coal basins. Parallel with this last axis and in the same long spur of the Mahanoy mountain, there is another diminutive trough of the coal measures, which is, in like manner, an extended arm of the great coal basin of the Mahanoy. The central axis of Head mountain, dividing these two lesser basins, is a low ridge of conglomerate rocks, which, if traced westward will be found to be identical with the great anticlinal axis of Locust ridge which separates the two main basins of Shamokin and Mahanoy. The great basin of the Mahanoy valley terminates westward in a knob of the main mountain, forming the south boundary of the Mahanoy basin, at a point about two miles south of the Shamokin mines. This knob faces westward upon the Red Shale valley, which lies between the north Mahantango ridge or Line mountain and the south boundary mountain of the Shamokin basin.

From this point eastward, the valley gradually increases in breadth and depth as far as the western commencement of Bear ridge, when it reaches its greatest expansion. The great anticlinal axis of the Bear ridge, rising in the centre of this coal basin, divides it into two large branches. The northern one of these, or the basin of the Shenandoah valley, if traced eastward, will be found identical with the southern coal trough of Head mountain above described. The other lying to the south of Bear ridge, after continuing eastward about five miles is there subdivided by another similar axis but of less elevation. The two troughs thus formed contracting and rising, extend eastwardly into two long spurs or fingers, the more northerly of which terminating in a high knob facing the south branch of the Quakake valley, feeds the sources of the Mahanoy creek. The southern of these synclinal troughs on the other hand, heads eastward in a knob

called the Hossasock mountain, reaching out from Mahanoy mountain into the Locust valley. A third, but smaller basin also takes its rise in this knob of the Mahanoy mountain, and terminates near the summit of the steep plane on the Danville and Pottsville rail road. South again of this last shallow trough, is another, taking its rise in a knob of Broad mountain, which faces the Nesquehoning valley towards the east, being a coal basin of little depth or consequence at its origin, but which may readily be traced and will be found to be identical with the central basin of the Broad mountain. The basin which we mentioned as terminating at the head of the steep Mahanoy plane, would, if continued, pass into a narrow coal trough lying along the northern edge of Broad mountain, and ending in a shoulder or knob on its western escapement opposite the junction of the Great and Little Mahanoy creeks. The central basin of Broad mountain, (in which is Spohn's tavern on the turnpike,) terminates westwardly in a spur jutting forward from Broad mountain towards Lykens' valley. This spur contains also the heading of a second very shallow and less obvious basin lying immediately to the south of the former, but which is of small consequence, as it seems to contain not even a remnant of the coal measures. This, and a third still narrower one may be seen at the passage of the Centre turnpike over Broad mountain. It is doubtful if either of these three last mentioned mountain troughs contains any considerable quantity of coal measures. Beside the spur of Broad mountain which we have just mentioned as jutting westward, two others are conspicuous in the same neighborhood facing upon the Lykens' valley. These two prominences of the plateau of Broad mountain, (the most southerly of which is the longest, extending itself several miles towards the west,) contain *two branches of the Mine hill coal basin*. The central valley of red shale dividing these two knobs, contains an anticlinal axis which may be seen terminating in the Mine hill valley, about a mile west of Coal Castle. The axis next south of this, which may also be traced for a great distance along the valley of Pine creek, and upon which this creek has its source, is *the true axis of the Mine hill*, dividing the Pottsville from the Mine hill basin. This in its turn, terminates in the neighborhood of Tuscarora, where this basin of Mine hill coalesces with the great southern one, or that of Pottsville and Mauch Chunk. Such is a general outline of the districts which have been embraced by our researches and surveyed in considerable detail during the past season.

The great southern coal valley of Pottsville, has also been in many of its parts minutely explored. In the course of this investigation, the situation of numerous important points was referred to a map; all disturbances of the strata that came under notice, were traced as far as possible or to their terminations, and their extent and direction ascertained, with a view to the discovery of the *general laws*, regulating the disturbances of the strata in this intricate but valuable region.

Particular observations have been made, with a view to form an opinion as to the capacity of the Bear ridge district, as a productive coal field. The present position of the Bear ridge tunnel, seems to adapt it very perfectly for an opening and outlet to the main body of the coal field north of it. The Bear ridge, is, as we have already indicated an anticlinal axes, coming in from the Quakake or Locust valley and dying out in the centre of the coal basin near Girardville. This axis, from its origin at Girardville, increases in elevation eastward, bringing up first the lower coal measures, to the surface, with their coal beds as at the tunnel, and afterwards in succession, all the conglomerates and other rocks to the underlying red shale which appear first near Brouse's tavern, on the Catawissa road. At the tunnel we have two or three coal beds rising from the vale of Mahanoy creek at an angle of from sixty to fifty degrees, which after saddling the ridge, dip rapidly downward to the north at an angle, increasing from ten to thirty degrees as we follow them more deeply. But in addition to those beds which pass over the ridge without fairly cropping out upon the surface, we have upon the northern side and superimposed upon them six or seven others, many of which must be of considerable thickness. The vale of Shenandoah, into which these north dipping coal beds descend, is a long narrow valley about one-third of a mile in breadth, reaching eastward to the sources of Shenandoah creek, and westward to a little beyond Girardville. The dip of the coal measures upon its northern side which is formed by the south flank of Locust ridge, is south. This, with the northern dip of the strata of the Bear ridge forms a regular synclinal trough whose eastern prolongation terminates only in the end of the Head mountain, of whose southern basin it is the true continuation. The denudation in this basin opposite Bear ridge has been comparatively small, a great depth of coal measures still remaining on both sides of the valley. So far as we may judge from external indications, these are remarkably regular and free from anticlinal or other

disturbances. Considering these circumstances, we may readily conceive, that great advantages would follow the completion of the present partially finished tunnel through the Bear ridge. Not only would all the coal beds of the south and north sides of Bear ridge be made accessible to the miner, with an uninterrupted range to the eastward for many miles, but the tunnel being driven at a level of only sixty feet above the level of Shenandoah creek, might form an outlet for all coal mines east of that point on either side of the basin.

A set of Geological specimens has been collected illustrating all the beds of the conglomerate, and the coal measures of the Bear ridge and Mahanoy mountain. A large collection of fossil impressions of the coal plants has also been gathered from the rocks of the tunnel.

In the great southern basin, the operations of the survey during the latter part of the season have been directed to the elucidation of a subject of the greatest interest to the miner and the land owner in this region; I mean the disturbances of the coal beds and their included strata. To this end, the dip, thickness and peculiarities of stratification of the coal beds have been obtained at the principal openings, their distances measured, their positions, as far as practicable, traced upon a map of an adequately large scale, and attempts made wherever any hope of success appeared, to identify the beds at distant openings. All the anticlinal disturbances which time permitted us to trace, have also been carefully noted, and a number of remarkable faults observed, with a view to ascertain, if possible, some rule respecting their directions and influence upon the strata. From the large number of specimens taken during the last season from this district, it was deemed unnecessary to collect many of these in the southern basin, excepting in a few instances.

A few of the conclusions arrived at, will serve to explain the nature and results of these investigations.

From the comparison of a great multitude of facts we are led to conclude that the southern coal basin throughout its whole length, is traversed longitudinally by several great *lines of disturbance*, in the range of which may be found a greater number of faults, downthrows, and longitudinal displacements of the strata and the coal beds, than can be discovered in the belts intervening between them. These lines of disturbance are indicated either by regular anticlinal elevations, which commence and terminate in distances varying in length

from a few hundred feet to several miles, or by simple but sudden changes of the dip, (the rocks not forming a complete axis) or by crushed coal seams where no disturbance in the adjoining rock is visible. Of the first kind of irregularity, the Bear ridge east of Port Carbon and the axis of Peach mountain are well known instances; the second kind may be observed in the rather sudden change of inclination at the foot of Mine hill, from steep south dips of sixty, to gentler ones of ten or even five degrees south. For the latter, we may refer for illustration to the beds of the barren tract and the faulty portions of the Gate vein. Passing over the eastern portion of the basin through which, indeed, anticlinal disturbances are well known to pass, let us commence with the Sharp mountain at Middleport, near Pottsville.

From this eastward to a point south of the above mentioned village, the rocks of Sharp mountain being overtilted or inverted towards the north, have a steep southern dip; at this point, however, we find them changing to a perpendicular position, and from this rapidly to a north dip, then to a west, and again to a south one, the last being gentle and not exceeding thirty degrees. In these changes, the southern or outward base of the mountain sweeps sharply round in the form of a bold promontory, and the returning or northern side of the spur contains the last mentioned southern dips.

Again repeated, but with less steep inclinations of the strata, we have the same series of changes, after which deviations, the mountain assumes a course of forty-four degrees east of north for some miles, and then continues in its ordinary range. It is easy to conceive, without entering into theoretical considerations, that these disturbances have been caused by the intrusion of two anticlinal axes which have their origin in the Red Shale valley, between the Second and Sharp mountain. These seem soon to flatten out and disappear within a short distance to the west in the coal basin, but in the several anticlinal elevations and the numerous faults of the Bear ridge, we have evidence of a disrupting effect prolonged much further in that direction. We lose sight of this line of disturbance near Port Carbon.

Passing towards the western extremity of the basin, we perceive two great anticlinal axes entering it from the west from Williams's valley, the southern and lesser of which is probably prolonged eastward, through the range of the barren tract, noted for the crushed

character of its veins of coal, while the other, a far more important axis, passes along the central part of the basin, producing, as far as evidence goes, the Minersville disturbances, (which may be seen in certain coal beds worked by Spencer & Co.) and in others, less known, some miles west of these, and prolonging itself further eastward into the great Peach mountain axis itself.

Our next conspicuous range of disturbance in the coal measures, lies along the foot of the Mine hill, but is of a less striking nature than the former. By its influence, the flat beds of the Mine hill seem to have been brought to their present posture. The crushes and rolls in Neighley's, and some other of the Mine hill workings, present other examples of this line of dislocation.

From the above and other analogous details, we conclude that the number of coal beds at present worked in this district has been somewhat over rated, for, in no instance can a north dipping bed be found, to which there are not two related south dipping portions. Thus the Lewis and Spohn veins opened upon the workings of the North America company's lands, must be considered as identical, having a north dipping or perpendicular bed, and none other between them. In consequence of this fact, all attempts to trace the Lewis and Spohn veins as separate beds, either eastward or westward beyond where they are already known, will probably prove abortive. One vein alone can be hoped for, unless the dislocation is prolonged to a greater distance than present evidence indicates.

SECTION 3.

A general sketch of the operations of the survey in the third or south-western Appalachian district.

In conducting the examination of the third district of the State, or that which is occupied by the half of the Appalachian chain, included between the Susquehanna river and the southern boundary of the State, the exploration was begun at the north-eastern extremity of the region in Union and Lycoming counties, and pursued regularly towards the south-west, following the course of the formations. The season was commenced with the survey of that portion of Union county, known as Buffalo valley, and as it was deemed judicious to confine our attention for the season, to a tract of moderate breadth, the lower part of Union county, situated to the south of New Berlin and Jack's mountain, was reserved for an ensuing year.

The strata underlying the broad surface of Buffalo valley, belong, with the exception of one or two small patches of formation No. VIII, near Lewisburg, to formations V and VI, the general composition and prevailing mineral contents of which will be found described in the last annual report.

As formation V of our series, is the depository of the valuable and interesting *fossiliferous iron ore* found in such considerable abundance in the eastern half of Montour's ridge, in Columbia county, it was deemed of consequence to the interests of Union county, to examine the red and variegated shales and sandstones of which this formation consists, with all the minuteness compatible with the rather obscure developements of the strata in most parts of Buffalo valley. A remarkably near approach to identity being discoverable between the several members of this great fifth formation as seen in Buffalo valley and in Montour's ridge, it was not difficult to recognize, from the examinations and measurements undertaken the previous year in the latter neighborhood, the precise layers which should contain the fossiliferous iron ore, supposing it to exist at all in Buffalo valley. This valley encompassed on the north and west by the terminating spurs of the broad belt of mountain ridges that crosses Centre and Mifflin counties from the south west, the lines of elevation of these

hills prolonged beyond their extremities, are traceable as far as the Susquehanna river, uptiling the strata in Buffalo valley, in such a manner that their beds are arranged in at least six nearly regular and parallel troughs.

In the upheaving of the strata along these several adjacent lines, the soft rocks of formation V, as well as the equally destructible layers of the limestone which overlies it, have been subjected to a very wide spread action of the floods, which at one time evidently swept down from the neighboring mountains. The consequence has been, that the uppermost of these rocks, the limestone formation VI, remains in but two narrow belts in Buffalo valley, composing in the one instance the limestone ridge south of Youngmanstown, and in the other, Dale's hill, directly west of Lewisburg. In each case, the preservation of the limestone stratum has been the result of the trough-like position of its beds, which has defended them from the currents that have carried away the more exposed portions of the rocks lying nearer the lines or axes of elevation. Where the trough or synclinal axis of Dale's hill crosses the Susquehanna, a narrow belt of formation VIII has, from this circumstance, been also preserved, the dark slate characteristic of the bottom layers of that formation, having been left about one mile north of the town of Lewisburg.

This undulating position of the rocks in Buffalo valley, accounts for the great width over which a single stratum, namely, formation V, is there spread out. By repeatedly bringing to the surface the same portions of the deposite, this feature greatly facilitates the search for any imbedded mineral layers, such as the fossiliferous iron ore of this formation.

But notwithstanding a long continued and minute examination of the rocks thus extensively exposed, the fossiliferous iron ore has only in a few places been satisfactorily developed, while in no instance does it exist as a stratum of sufficient thickness to render it an object of much interest to the manufacturer of iron. No uncertainty can prevail respecting its position in the formation, which agrees entirely with that occupied by the thicker band of ore of Montour's ridge, now extensively worked. In one instance, in which we have met with this ore, namely, on the farm of Messrs. Dersham and Rank, about three or four miles from New Columbia, the apparent thickness of the ore was about seven inches, which is not sufficient to induce any attempt at mining it. It was found in another case in the

same relative position, to the beds of the red shale and sandstone formation, on the land of Aaron Chamberlain, but though the fragments of the ore are numerous on the surface of his fields, no layer of the mineral having much thickness has been discovered. Nearly one mile south of Lewisburg, along the river side, several thin seams from four to six inches in thickness have been found. They are very fossiliferous, being of the hard calcareous variety and would not justify the expense of mining them. The ore also occurs near Miller's saw mill, on Penn's creek, on the property of Robert Shippen, but as no excavation has yet been undertaken, its thickness remains unknown. Near this place there occurs a ferruginous bed of rather peculiar aspect. It consists of small particles of quartz, firmly cemented together by oxide of iron, and is between two and three feet in thickness.

Besides the fossiliferous ore now mentioned, which is peculiar to formation V, we have met with an entirely different variety in several places in the western part of Buffalo valley, occurring in the same formation, but to all appearance connected with the shales which occupy a rather higher position in the stratum, than the calcareous fossiliferous beds associated with the fossiliferous ore. This variety is a brown argillaceous ore, of a shelly and coarse honeycomb structure, its cavities being usually occupied by an unctuous yellow clay, the predominant material of the soil in which it rests. An ore very similar in structure and composition occurs in our formation VIII, in Perry county, and a variety somewhat analogous, is to be met with quite frequently in the slates or shales of the bituminous coal measures of the western and northern counties, where the kidney ore has acquired nearly the same aspect at the outcrop of the strata, by the decomposing agency of the atmosphere. A mine of the kind of ore above spoken of, occurs about one mile south of Miller's saw mill, and has been somewhat extensively worked. Another deposit of the ore similar to the last in character and in its geological relations, occurs about six miles west of Millers'.

After the detailed examination of Buffalo valley, a few only of the results of which are here presented, was concluded, our explorations were extended to the mountains which skirt it on the west, afterwards to White Deer Hole valley, and subsequently to all that part of Lycoming county lying south of the base of the Allegheny mountain.

Moving forward in a south-west direction, we next entered Centre county, which was examined from the base of the Seven mountains to the base of the Allegheny, as far westward as the end of Nittany mountain. There remain, however, a few small neighborhoods in the district here specified, the true Geological structure of which was not fully ascertained for want of time. Some of these will be mentioned in this chapter. With these exceptions, the region designated has been, it is believed, adequately explored, its curious and highly intricate Geological structure unravelled, and some important advances made towards the laws which influence the distribution of its mineral resources.

I shall now describe as succinctly as possible, the Geological features of the region explored, in order to convey more definitely some idea of the situation and extent of the several formations which it includes. A true knowledge of these features is indispensable to the successful tracing of any useful mineral deposits.

FORMATIONS INCLUDED IN THE DISTRICT EXPLORED.

Confining our present descriptions to the country south of the base of the Allegheny mountain, the formations of the portion of the district explored are, first, the great blue limestone of the valleys of Centre county, or formation II; secondly, the slate, which in all cases skirts the margins of these valleys, or formation III; thirdly, the sandstones, or formation IV, which compose the Bald Eagle mountain and all the other high ridges south of it; fourthly, the red and variegated shales and sandstones, or formation V, which have already been referred to as composing the chief part of Buffalo valley, and which occur also in White Deer Hole valley, and range along the northern base of the Bald Eagle mountain throughout the whole of its course; fifthly, the blue fossiliferous limestone, or formation VI; sixthly, the fossiliferous sandstone, or formation VII, a thin stratum in this region and sometimes entirely wanting; and lastly, formation VIII, all of which three latter rocks are confined to the valleys above spoken of, as containing formation V.

In the section of the country to which reference is now made, formations II and III are confined to the fertile agricultural valleys of Centre and Lycoming counties, which lie to the south-east of the Bald Eagle mountain. These valleys are, Nittany valley, Sugar valley, Little Sugar valley, Brush valley, Penn's valley and Nippenose

valley. In these beautiful and deep valleys between the mountains, formation II occupies nearly the entire surface. Formation III, being a stratum of far less thickness, and usually dipping away from the limestone under the base of the adjoining ridges, is restricted to a narrow zone, begirting each limestone valley with a margin of slate. The several beds of formation IV, constitute all the higher mountain ridges of the district, viz: the Bald Eagle mountain, the several branches of Nittany mountain; also White Deer mountain, Brush mountain, Short mountain and the long complicated range called the Seven mountains. Formation V spreads largely over Buffalo valley, and it occupies a belt in White Deer Hole valley ranging in another narrow tract to the end of Bald Eagle mountain, around the extremity of which it doubles to the westward, following the base of this ridge throughout its whole course by the valley of the Susquehanna river and the Bald Eagle creek.

Formation VI has a more local range; it composes, as before said, the limestone ridge near Youngmanstown, and that called Dale's hill, both in Buffalo valley; and it is found in White Deer Hole valley, on both sides of the western termination of the Muncy hills; it occurs, besides, in an almost uninterrupted range near the middle of the valley included by the Bald Eagle and Allegheny mountains.

Formation VII, owing to its greatly reduced thickness in this part of the State, and to its very destructable nature, being a porous and loosely cemented sandstone, is more rarely to be seen, though it shows itself in places along the middle of the valley which lies north-west of the Bald Eagle mountain, in close connexion with the limestone just referred to.

Formation VIII, or the olive coloured slate and sandstone stratum, displays itself in a small patch in Union county, (consisting of only its lower beds,) in the neighborhood of Lewisburg. It also enters our present district forming the western portion of the Muncy hills, and occurs in a long and heavy belt two or three miles in width, skirting the southern or south-eastern base of the Allegheny mountain, throughout its entire range, not only in Lycoming and Centre counties, but entirely across the State.

In order to have a correct conception of the Geology of the parts of Centre, Lycoming and Union counties, that have been examined, it is necessary to dwell, as briefly as possible, upon some of the

leading features of the region. From the valley sometimes called the Lewistown valley, which runs through the centre of Union and Mifflin counties, to the base of the Allegheny mountain, to the north-west, the whole included broad belt of country, consists of a succession of nearly parallel mountain ridges, remarkable for the straightness of their course, the even outline of their summits, the general similarity of their form, and their uniform height above the intervening valleys. Between these ridges we have a series of long, narrow and nearly straight limestone valleys, the southernmost of which is Kishacoquillas valley, in Mifflin county, while on the north-west, are Nittany and Nippenose valleys, in a line with each other.

Now such is the necessary dependence of the Topographical features of any diversified region upon its Geological structure, or, in other words, so entirely have the present bold and singular outlines of this district, been impressed upon it, by the agency of causes strictly Geological, namely, by the upheaving of the strata along certain lines and the simultaneous destruction of large portions of them, by the scooping action of a mighty flood, that we shall be much assisted in any effort to comprehend the intricate Geography of this region, by devoting a moment's attention to the following Geological views.

Of the seven formations enumerated above, as comprising the rocks of the portion of the State before us: formations II and III, are respectively a limestone and a slate stratum; which are at all times more destructable than sandstone; but especially so, must they have been in their soft or pulpy state, at the time of their elevation from the bed of the ocean, in which they were deposited.— Hence they have been more deeply excavated than the harder ponderous beds of sandstone of which formation IV consists. We accordingly find formations II and III, always in the deep and nearly level valleys, and formation IV, in the high and steep mountain ridges. Of the other rocks, formation V consists chiefly of soft slates and calcareous shales. Formation VI, of limestone, which, like formation II, was evidently of a very soft consistence, when first uplifted, and formation VIII, of a mass of slate and argillaceous rocks. These would all be liable to very extensive destruction, whenever subterranean uplifting forces would bring them within the reach of those tremendous currents, which those same uplifting actions set in motion.

It comports entirely with these views, that we find these destructible rocks restricted to the valleys or broad plains between the sandstone mountains. In the district before us, we see them confined to the Buffalo Valley, White Deer Hole Valley, and the valley at the base of the Allegheny mountain. Unless where formation VII, a sandstone stratum, dwindles to quite insignificant dimensions, it composes a steep and sharp ridge, though from its small thickness, this is always of unimportant height, when compared with the mountains that contain its more massive prototype, formation IV. These facts and others of a like character, are all important in their applications; affording us often the best clue in an unexplored or intricate district in tracing the distribution of any bands or deposits of mineral matter, which we may be in search of. Thus in traversing any portion of the district between the Susquehanna river and the Maryland State line, in quest of the valuable fossiliferous iron ore, peculiar to certain layers of formation V, it is of extreme advantage to trace the stratum by aid of the topographical features which belong to it, and to its contiguous formations, and it is only by understanding the connection between these features and the agents concerned in producing them, that we can with any success detect the stratum we are searching for, if any irregularity has thrown it out of its more ordinary position. The evidence of this will be manifest, in relation to the band of ore alluded to, when we come to another part of this report.

Bearing carefully in mind, therefore, the difference in the destructibility of the several rocks, while under the action of the currents, which have rushed across them with such tremendous violence, sweeping off all their more exposed portions, let us advert to the operation of those subterranean upheaving forces which seem to have acted on the strata with such resistless energy, uplifting, inclining and dislocating them in certain lines, which we now proceed to trace. By these two causes we shall account for all the features in the Geology and Topography of this intricate region. I shall, therefore, describe as concisely as possible the *lines of elevation* of the strata, or technically, the *anticlinal lines*, and at the same time the *lines of greatest depression or synclinal lines*, which range through the valleys and ridges of the district, and shall offer also a brief description of the Geology and mineral contents of the belts of strata, which they disturb.

NITTANY VALLEY AND ITS ANTICLINAL AXIS.

This valley, properly speaking, commences at the south-western extremity of Nittany mountain, where the broad Half Moon valley is divided by the mountain into this, its wider branch on the north, and Penn's valley on the south. It is bounded on the south-east, by the Nittany mountain, and on the north-west, by the Bald Eagle mountain. Where Nittany valley opens into the Half Moon valley, it is about six miles wide, but as we advance north-eastward its width contracts to between four and a half and five miles opposite Bellefonte, and three and a half or four miles opposite Howard's gap, nine miles from Bellefonte, and to about two and a half miles opposite Millhall. Further east, the two converging boundaries of the valley unite, closing it up at a point nearly south of Dunnstown.

There is a central tract running through Nittany valley, between two and three miles in width, which is denominated the *Barrens*. It has a sandy and stony soil, is singularly destitute of water and remains therefore in its native uncultivated condition. It is here, that nearly all the large deposits of valuable brown argillaceous iron ore, which have rendered Nittany valley and its neighborhoods celebrated for their iron manufacture, are found. The surface of these barrens is considerably elevated, rising above the general plain of the valley into a ridge, which begins about two miles from Bellefonte, and extends eastward about twelve miles, where it subsides. From its termination, eastward to the head of the valley, cultivation extends entirely across from mountain to mountain. The features of this valley, indicate many departures from that more perfect regularity of geological structure, which prevails in several of the other valleys of anticlinal form, which lie parallel with it, towards the south east. The present report does not permit me, however, to discuss these local disturbances of stratification.

Though numerous irregularities in the dip of the strata prevail in some parts of the valley, they are inconsiderable, when compared with that general uniformity in the inclination of the beds, visible throughout its entire length. One great anticlinal axis runs through this valley from one extremity to the other. It is rather a portion of a still more prolonged axis of elevation, which is traceable from the neighborhood of Hollidaysburg, through the end of the Brush mountain, and thence along the Sinking Spring, Half Moon and

Nittany valleys, and still further through the middle of Nippenose and Musquito valleys and out through the end of the Bald Eagle mountain into the plain east of the Susquehanna, as far as Muncy creek. The position of this line from which the strata are tilted away in opposite directions, is not central through Nittany valley, except from the head of the valley to the neighborhood of Millhall. From this point south-westward, it is nearest the Bald Eagle mountain. All the strata which lie to the north-west of it, viz: the limestone beds of that side of the valley, the slate of formation III, which rests upon these and passes under the base of the Bald Eagle mountain, the sandstones of formation IV, of the same mountain, the rocks of the formations V, VI, VII and VIII, which occupy the valley between the Bald Eagle and the Allegheny mountain, all decline towards the north-west, with a greater or less steepness, the degree of inclination generally abating as we recede from the anticlinal axis to the slightly inclined rocks of the Allegheny. On the other hand, the rising of the strata along this axis has caused all those situated to the south-east of it as far as the summit of the Nittany mountain, that is to say, the limestone beds of the south-eastern half of the valley, the slate at the foot of the mountain, and the sandstone rocks of the mountain itself, to dip towards the south-east. The sandstone stratum, formation IV, dipping on the north-west side of the mountain, towards the south-east becomes horizontal along its centre, and displays on its south-eastern side, an inclination in the opposite direction, or towards the north-west, so that the rocks of the mountain lie in a trough form, technically denominated a synclinal axis. Such is the structure of this mountain opposite Bellefonte, and throughout several miles of its length, towards its western extremity; but further to the north-east it becomes somewhat complicated, both in regard to the dip of its strata and its topography. Further eastward, in place of a synclinal axis or trough in the rocks, there is an anticlinal axis, the same which brings up the limestone in Big and Little Sugar valleys, which divides the mountain into two branches. As we advance still more towards the north-east, each of these branches of the mountain in its turn, becomes subdivided by other similar short axes of elevation. In consequence of these numerous parallel upliftings of the strata of this mountain, there are many alternations of dip in the rocks, from south east to north-west, and hence the topography of the chain being intimately dependent upon these circumstances, has acquired a highly complicated character.

Of the rocks of Nittany valley I have already stated, that the great blue limestone stratum of our state, formation II, occupies almost the entire surface of this valley, even capping in most places the sandy ridge, called the barrens. The character and quality of the rock, however, varies greatly in different belts. Beginning with the lowest beds visible, or those which have been brought to the surface by the movement of elevation acting along the anticlinal axis, we find immediately adjacent to this line, lying along the central ridge or barrens, many masses of sandstone, evidently derived from the underlying beds of formation I, but in no instance have we yet found that rock in place. In other parts of this central ridge, the limestone, formation II, shows itself, possessing in some degree the sandy composition of the inferior rock. Receding a little towards either side of the valley, or in other words, ascending into rather higher portions of the stratum, we meet a moderately thick body of tolerably pure limestone, which contains, however, some layers of sandstone. Above this, there occurs a pale blue rock in numerous beds, having a very close resemblance to limestone, but singularly enough, containing little or no calcareous matter, being in fact, a very pure and fine grained siliceous rock, a species of compact chert, both in its texture and composition. The next belt in the ascending order, comprises a large body of very excellent limestone, most generally of a very pale bluish aspect. In this, there frequently occur seams of white calcareous spar. Higher still in the formation, or, indeed, in its uppermost subdivision, some of the beds are more or less bituminous, which they indicate by their sooted smell, some are decidedly argillaceous, manifesting a close approach to the immediately overlying slates of formation III, and others are characterised by a profusion of fossil shells and other marine remains. These are the fossiliferous bands of formation II, at least in this region of the State.

The upper layers approaching to the slaty rocks of the next overlying formation, III, contain a large amount of argillaceous matter. A little higher in the stratum, these beds alternate with numerous dark blue or almost black bands of calcareous slate, having a remote analogy in their appearance to those slates which lie in contact with seams of coal and consequently many abortive attempts have been made to discover coal in these rocks, not only in Nittany valley, but in the other limestone valleys which occur to the south-east and even

in many places in the great Kittatinny valley where these rocks are largely developed.

The soil derived from these dark calcareous slates which occur among the alternating bands interposed between the main masses of formation II and formation III, is deservedly esteemed to be among the most fertile in the State, being admirably adapted to the cultivation of wheat. This is well exemplified in the productiveness of some of the farms in the eastern part of Penn's valley, where the soil of a considerable tract of country has been derived from the source mentioned. The cause of its productiveness is obvious; while that from the slate is comparatively unproductive, owing to the excess of clay which it gets from that rock and to its almost total destitution of lime, and on the other hand, while that which rests upon the limestone, though of better composition and texture is scarcely more impregnated with calcareous matter, in consequence, probably, of the facility with which the lime has been removed by the percolation of water through its open materials, the soil of these intermediate strata which have a sufficiency of lime in their composition, would appear to be perpetually replenished with this valuable ingredient from the facility with which the soft rock moulders down after ploughing and crumbles into mellow earth by the action of the atmosphere.

Formation III, which is a mass of fissile slate of various colors from light yellow and grey to dark blue and dingy olive, exists as a stratum of several hundred feet thickness, ranging in a belt along both the south-eastern and north-western margins of the Nittany valley, and extending commonly up the flank of each of the bounding mountains from a little outside of the base to within about one third of the total height from the summit. The lower layers, contiguous to the underlying limestone, are those which are most apt to be calcareous and to contain fossils, though these distinctive features belong also to some of the higher beds. In Nippenose valley some parts of this rock are highly fossiliferous, and the same remark will apply to the upper beds of the underlying limestone seen in that singular valley.

The strata of Nittany valley have been dislocated to an extent not witnessed in the anticlinal valleys which lie more to the south-east. But the disturbances prevail almost wholly along the north-western side of the valley, especially close to the foot of the Bald Eagle mountain. The irregularities in the dip of the rocks are traceable from Millhall, to nine or ten miles south-west of Bellefonte, and by

observations made during a former season, I am led to think that they continue the whole way to the Little Juniata. The inclination of the strata to the south-east of the main central anticlinal axis is never steep, rarely exceeding thirty degrees.

Though a great number of excavations for iron ore were visited in Nittany valley, many of which are highly interesting from the richness of the ore, and the prodigality in which the mineral is supplied, and from the curious features, seen sometimes in the deposits in their connexion with the underlying limestone strata, yet no satisfactory explanation has been arrived at concerning the origin of the ore, nor any general practical rule discovered, calculated to conduct us with a desirable degree of certainty, in our search after large deposits of the mineral. Some light has, however, been gained from other quarters of the State, through observations made upon the same formation. If these should be corroborated by future researches, some part of the obscurity which rests upon this difficult, but important subject, may perhaps be removed. For the present, I deem it premature, until the chemical examinations connected with the survey shall have been more advanced, to enter into the complicated enquiries arising out of the scientific investigation of our ores of iron.

FORMATION IV, AS IT OCCURS IN BALD EAGLE AND NITTANY MOUNTAINS.

The Bald Eagle mountain, the boundary on the north-west of the three valleys of elevation, Nittany, Nippenose and Musquito valleys, consists of the sandstone rocks which constitute formation IV, uptilted towards the north-west, generally at a high inclination from the anticlinal axis, which traverses those three valleys in a longitudinal direction. From its eastern termination at the Susquehanna, near Muncy, the outline of its summit is remarkably level and regular, until we reach the eastern end of Nittany valley, where the profile of the ridge becomes rather more undulating, its line of direction less straight, and its height somewhat diminished, all natural results of the disturbances near its south-eastern base in Nittany valley. Between Musquito valley and the ending of the mountain at the river, it is a single ridge with a finely rounded summit and contains the anticlinal axis running centrally through it. But westward from that point its strata dip in but one direction, or towards the north-west, and it exhibits throughout its whole length, two distinct parallel

ridges with a considerable depression between them. These two summits are usually not more than a fourth of a mile apart, and possess about the same elevation, though not unfrequently the northern ridge rises above the other, attaining a height nearly as great as that of any of the other mountains in the region.

By adverting to the nature of the rocks composing formation IV, we find a ready explanation of all the features of Bald Eagle mountain, applicable, not to this ridge alone, but to all the high ranges in the district which consist of this stratum. The formation embraces three distinct sets of beds; the uppermost and lowermost being massive sandstones, while the middle member is composed of soft argillaceous red sandstones and red slates. The lowest of these divisions is generally a grey sandstone, sometimes greyish or white and occasionally bluish, and in some ridges includes beds which are green in color and very tough. All these varieties are very hard, though the weathered fragments do not show such sharp edges as those belonging to the upper division of this formation. Among these grey sandstones we find fossil remains of the Zoophytes, the class containing the corals, while in no instance have we met with these in the upper division. These lower strata of formation IV, compose the south-eastern ridge of Bald Eagle mountain, and extending our remarks to the other mountains, they belong in general to that ridge which is immediately adjacent to the limestone valley, or in other words to the anticlinal axis. The sandstone beds grow less compact as we approach the middle part of the formation, and acquire a more greenish hue and become speckled with brown oxide of iron. The central division of the mass consists, as already mentioned, of soft red argillaceous sandstones which are similarly speckled and interstratified with red slate. The upper member of the formation is a hard white and grey sandstone of even texture and often of extreme purity, easily distinguishable, if not recognized by its relative position to the other strata, by the frequent occurrence on its surface of a class of singular impressions formed by a marine vegetation called *fossils*.

It is to the unequal destructibility of these three belts of rock, under the violent wearing action of a flood of waters which has rushed over their upraised edges, that we are to attribute the double ridge and the included valley on the top of the Bald Eagle mountain. The comparatively soft middle stratum, has been there scooped to a

considerable depth below the more resisting sandstones which lie on either side of it.

In consequence of the triple character of formation IV, we invariably find the mountains that are composed of it, to consist of *two* ridges when the strata dip in the same direction, or when they contain no axis, either anticlinal or synclinal. But whenever an anticlinal axis upheaves these rocks, exposing the lower sandstone, then the mountain contains *three* ridges, the axis of elevation being in the middle of the central one. And when, on the other hand, a synclinal axis or trough-like dip of the strata extends through the middle of a mountain, consisting of formation IV, it then contains *four* separate ridges, the two outer ones caused by the sandstone of the lower division, the two inner ones by the upper sandstone member of the same formation. Guided by these facts, which are the necessary results of Geological causes, we trace in the perplexing intricacies of the geography of the mountain chain, which passes through the counties that lie between Maryland and the Susquehanna river, the most beautiful symmetry in the structure and connections of all the ridges. Were geographers, while mapping our mountain region, to make themselves familiar with the dependence of the configuration of the region upon its Geological structure, they would discover that the unerring rules of the science constitute their surest, or often their only clue, to those features of topography which it is their business to depict.—The confusion and distortion, so conspicuous in our present maps, would give place to features of curious and pleasing regularity, and to accuracy of delineation nowhere to be seen, while in the details, the benefits conferred by maps on the traveller, the engineer and the miner would be tenfold enhanced. By adhering to the views above presented, we have been enabled to reduce to order nearly every part of the seemingly complicated topography of the mountain ranges, which embrace the Bald Eagle, Nittany, White Deer, Brush and Seven mountains, and their subdivisions, and to trace the existence or absence of particular mineral beds suspected to occur in these wild regions. We have thus succeeded also in collecting some valuable materials designed to correct the present map of the State, or to contribute towards the construction of a better one.

Omitting a description of the curious Geological and Topographical structure of the Nittany mountain and its branches, which would require the assistance of maps and profile sections of the district, not

suited to the plan of the present report, I shall proceed to mention in few terms, some of the other parts of the region, and to trace those axes of elevation which have imparted to each tract, its particular Geological structure and mineral resources.

The anticlinal axis of Nittany valley, prolonged as before mentioned, to the eastward, has elevated the limestone rocks composing formation II, to the surface in Nippenose valley, causing the strata to dip at a gentle angle each way from this line, which runs nearly along the centre of the valley. This valley is remarkable for its regular oval form, being an ellipse of about ten miles in length and four in its greatest breadth, and for the height and steepness of the rim of mountains which encompass it. The only avenue to it, without crossing a high zone of mountain land, is by a deep notch in the Bald Eagle mountain, nearly opposite Jersey Shore. The base of this notch is on a level with the surface of the valley, and hence through it, all the waters which enter the valley find their exit into the Susquehanna river. It is a remarkable feature about the drainage of the valley, that the numerous streams which descend into it from the surrounding mountains, all disappear through the funnel-shaped depressions called sink-holes, which abound over the surface of the limestone stratum of this valley, and what is not a little curious, the whole united body of these waters gushes forth to the surface again in a bold stream, passing through the mountain notch or gap, to which allusion has been made. A quarry of marble was opened and wrought with some spirit in this valley by Mr. Lawrence Wells. It is near John Bixler's tavern, three and a half miles from Rhodarmel's. The marble is a compact, dark, blue limestone, variegated by thin veins and specks of yellow crystalline carbonate of lime, or occasionally of white calcareous spar. The quarry has since been neglected. Layers, yielding similar marble, may be found near the centre of the valley east and west of this point.

Though minute attention was directed to the discovery of *iron ore* in this valley, the search has been to a great degree unavailing. Two circumstances discourage the hope of readily finding ore in any considerable quantity: first, the small depth beneath the surface at which we find the limestone rock; secondly, the absence of that bright yellow stain in the soil, which is so good an index of ore in Nittany valley. The soil here is generally dark brown or reddish.

The next limestone valley of the district is Sugar valley, formed by an anticlinal axis which has uplifted to the surface, the limestone rocks of formation II, between two of the branches of the Nittany mountain, a few miles east of the Bellefonte turnpike, and which passes along the centre of Sugar valley to its termination, and thence through the middle of White Deer mountain to its end, where the axis, leaving the ridge, passes out into the plain occupied by the higher formations of the series east of the river. In Sugar valley, the strata on the northern side of the axis have a steeper dip towards the north than those on its southern side have towards the south.

Our researches for ore in Sugar valley have not been completed, having been interrupted by the snows at the close of the season. A furnace for smelting iron was erected some years ago, about five miles to the east of Kleckner's tavern, but though the iron manufactured was pronounced to be of a superior quality, the supply of ore was insufficient to sustain the furnace. Of a number of excavations for ore which were visited, nearly every one seems to have been arrested at the depth of ten or twelve feet, by the underlying solid rock. This and other facts would appear to indicate a probability, that no extensive deposits of ore will be readily found in this valley, though further explorations are necessary to establish such an opinion. Sugar valley has an average breadth of nearly two miles, and is sixteen miles in length, the limestone which every where underlies it, being traceable to a point nearly seven miles east of Kleckner's. Between Sugar and Brush valleys, there are three distinct ridges, the middle and highest containing a synclinal axis in the upper member of formation IV. Towards the eastern end of Sugar valley, the topography of the mountain bounding it on the south, becomes more complicated.

The anticlinal axis, next south of that of Sugar valley, lies in a ridge called Nittany mountain, from the eastern end of which it is traceable to the Susquehanna, which it crosses about three miles above the town of Milton. A much longer and more important anticlinal axis, which has elevated a beautiful and fertile belt of limestone, passes one mile north of Boalsburg, in Penn's valley, and extends along Brush valley, pursuing the northern side, generally within half a mile of the base of Nittany mountain. It upheaves the strata of formation II, which dip at a moderate angle, rarely exceeding twenty degrees. Running eastward, this line of elevation enters the middle

of Buffalo mountain, which it traverses to its termination. It afterwards emerges into Buffalo valley, where it inclines the red shale rocks of formation V, and runs to the Susquehanna near New Columbia. Brush valley varies between one and two miles in width, is remarkably level, owing probably to the gentleness in the dip of its strata, and is one of the most beautiful in the district. In consequence, probably, of the same cavernous character in the limestone, which exists to so great an extent in Nippenose valley, there is little or no water to be procured below the soil, in many parts of this valley, by wells, and the inhabitants have been constrained to conduct it to their dwellings in pipes from the adjacent mountains. Brush mountain, consisting of all the three divisions of formation IV, is composed of three ridges, in consequence of a synclinal axis passing along its centre. This trough in the dip of the rocks, continues eastward into Buffalo valley, and extends westward into one of the Seven mountains at Boalsburg, passing a fourth of a mile north of Old Fort.

In Penn's valley, we can trace one anticlinal axis running between Egg hill and Brush mountain, and a second lying further south between Egg hill and the Seven mountains. The more northern of these lines of elevation, may be found about a fourth of a mile from the foot of Brush mountain, near Millheim, and can be followed thence to where it passes about one mile south of the Old Fort, and onward until it enters the middle of a high knob of the mountain ending at Boalsburg, being there but a short distance south of the synclinal axis that extends from the middle of Brush mountain. Towards the east, it has produced the valley in which Pine creek flows, and which lies between the Short mountain and Brush mountain, forming a northern branch to Penn's valley. From the end of this narrow valley, its course is through the ridge which terminates at the gap or entrance into the Brush valley narrows, whence it probably extends to the Susquehanna, crossing a quarter of a mile below Milton bridge.

The Short mountain is composed of three ridges, being a mountain of synclinal structure. This trough is continued under Egg hill, and thence into a ridge which rises from the valley about five miles east of Boalsburg.

Following the anticlinal axis of George's valley, eastward, we trace it into Penn's valley narrows, between the Short and Seven

mountains, and thence into a mountain which ends nearly three miles eastward of Hartleton. Westward, this line of elevation in the strata passes into what is called the Loop, and thence directly through the Bear meadows, and out into Stone valley.

Notwithstanding the seeming complexity in the geological structure and topography of the Seven mountains, this range is extremely simple. Crossing it, for instance, on the Lewistown and Bellefonte turnpike, we discover the following features in the dipping of the strata, which belong to the three sub-divisions of formation IV.—After leaving Penn's valley, the dips are first south, then north, showing a *synclinal* axis, and further still we meet a second change to a north inclination, giving proof of another *synclinal* axis. Passing over these last north dips, we reach the bold anticlinal axes, which have brought up to the surface the limestone strata of formation II, in Kishacoquillas valley. The trough or *synclinal* axis, first met with south of Penn's valley on entering the Seven mountains, passes into Buffalo valley north of Paddy's mountain. This mountain contains an anticlinal axis, the same which forms the middle ridge of the Seven mountains. The southern *synclinal* axis or trough in the Seven mountains may be traced through Buffalo valley, along the middle of Limestone ridge, to the Susquehanna, nearly three miles south of Lewisburg, whence it may be prolonged immediately to the south of the anticlinal axis of Montour's ridge, though it probably dies out at the river. The axis of elevation just mentioned, after leaving Montour's ridge, continues westward in Buffalo valley, and dies out between Paddy's and Jack's mountains.

Kishacoquillas valley, a limestone valley of great beauty, and interesting for the abundance and purity of its iron ores, contains probably three anticlinal axes, though only two are traceable beyond it, north-eastwardly into Buffalo valley. One of these axes of elevation passes between the Seven mountains and the northern knob, which closes the valley towards the north-east. This knob contains a *synclinal* axis or trough in formation IV, and includes near its end three ridges, and further eastward four, by the forking of the middle ridge, which consists of the upper or white sandstone member of formation IV. The most northern of the two inner ridges, after running some distance, is joined by a similar ridge from the southern part of the Seven mountains, and the two closing into one mountain, form the White mountain with an axis of anticlinal structure. Its axis is pro-

longed through Buffalo valley, where it may be traced along Penn's creek, and further still into Longstown ridge. The point at which it is finally exhausted, or, what is the same thing, where the uptilted strata finally flatten down or change their dip, is not yet exactly known. The anticlinal axis which extends along the south-east side of Kishacoquillas valley, passes eastward between another knob at the head of the valley and Jack's mountain. The upper strata of these two close together over this line of elevation, which thence runs through the centre of Jack's mountain. This ridge has, therefore, a simple anticlinal structure from hence to its termination, two and a half miles west of New Berlin. At this point of the mountain it has gently elevated the shaly strata of formation V, affording us an opportunity for finding the fossiliferous iron ore, not only around the end of Jack's mountain, but along both the northern and southern flanks of the ridge, should it exist here in any conspicuous quantity.

Having endeavored in the foregoing account of the Geological structure of the parts of Union, Lycoming and Centre counties explored during the past season, to convey, as far as my present limits allow, some conception of the mode in which the formations in this quarter of the State are distributed, I shall conclude what I have to say on the third Geological district, by describing, as briefly as possible, the several belts of formation V, in its range between the Susquehanna river and the Maryland state line. I am induced to do this from a persuasion of the great importance to our iron manufacture in these counties, of the fossiliferous iron ore which occurs only in this fifth formation. I wish also to place on record at this time, some information respecting the range of the ore, in the hope that it may prove useful in directing the researches of the proprietors of furnaces, and others interested in the discovery of the mineral. The detailed and systematic examination undertaken for this highly valued species of iron ore, consumed a considerable portion of our season in Buffalo and White Deer Hole valleys, and the valley of the West Branch and Bald Eagle creek from Muncy to Bellefonte. Hereafter, it will be extended to every belt of the red and variegated shales which offer any reasonable indication of containing the fossiliferous ore. It may be expedient, in the mean while, to state results of various reconnoissances in parts of the district not yet accurately surveyed, by which the wide distribution of the ore has been established, and the directions in which it ranges at least approximately ascertained.

Before tracing the course of formation V, it may be useful to call attention to the part of the stratum, in which the fossiliferous ore occurs, referring for more minute details to my second annual report. The whole stratum, consisting of red and variegated shales and red sandstone, is susceptible of a natural sub-division into three members. The lowest of these is a dense and heavy sandstone of a dark brown color, having a decided tendency in its fragments to assume a square or cubical form. The middle division is made up of layers of shale or soft slate of various tints, the more usual colors being dull olive, bluish grey, yellow or buff, and dingy brown. Some of these layers, especially the olive colored ones, are often covered with the impressions of shells and other fossils. In this part of the stratum, there are also occasional thin bands of limestone, generally highly fossiliferous layers, that the bands of fossiliferous iron ore occur in, whenever they are present. The upper sub division of the stratum, is a rather thick mass of red or rather brown shale, of very crumbly texture and uniform aspect.

Upon formation V, the next in the order of stratification, is the blue fossiliferous limestone stratum, formation VI, of the series.

In consequence of formation V reposing on the great sandstone mass, formation IV, its lower and middle beds will be found to be almost invariably upon the flank, or at the base of the high mountain ridges, consisting of the latter stratum. This will always be the case, when the inclination of the rocks is considerable. In those instances where all the strata of the mountain dip, in one direction, for example in Bald Eagle mountain, the ore bearing stratum or formation V, will be found only on one side of the ridge, namely: the side remotest from the anticlinal axis, which has produced the elevation of the mountain, which being here the Bald Eagle mountain, the axis is that of the Nittany valley. But in other cases, where an anticlinal axis passes along the summit of the ridge, composed of formation IV, or in other words, where the rocks dip in both directions from the middle of the mountain, then there occur two belts of the ore, or at least of the stratum in which it alone exists. Such is the structure of Montour's ridge, in Columbia county, where a distinct band of the ore occurs along each flank, running for a distance of many miles. A similar conformation prevails in Wills' mountain, in Bedford; Jack's mountain, in Huntingdon; Shade mountain, in Mifflin and Union; and Tuscarora mountain, in Perry county. The

presence of the ore is indicated along nearly all of these ridges, but too little has hitherto been done in the way of a systematic exploration, to authorize my entering here into any further particulars, than to trace out the course of the formation which should contain the ore.

Commencing with its most north-westerly belt in the district, and indeed in the State, we can trace formation V from the eastern end of Bald Eagle mountain, along the north-west side of that ridge, at the base and upon the flank of which it reposes throughout its entire course, to its south-western termination near Hollidaysburg. In all this distance, the dip of the stratum, with a very few local irregularities, is towards the north-west, with various degrees of steepness. Here passing round the point of the mountain, the formation spreads out as far as that town, when the fossiliferous ore is sometimes met with in excavations, but its want of thickness, and the excess of calcareous matter which its numerous fossils give it, have prevented its becoming an object of economical interest. From Hollidaysburg, the formation containing the ore having doubled round the end of the Bald Eagle mountain, which is here called Brush mountain, ranges north-eastward to the head of Canoe valley, at the junction of the true Brush mountain with Canoe mountain. In this portion of its course, the prevailing dip of the stratum is towards the south-east. From the head of Canoe valley, it courses to the south-west, along the north-west base of the Canoe or Lock mountain, running into the little cove of Old Town run, thence north-westward towards Franks-town, before reaching which it folds round the end of Dunning's mountain, (here called Lock mountain,) and pursues from this point southward, the western flank of that mountain, to its termination about eight miles north of Bedford. Folding round the spur which Dunning's mountain here throws forward to the south, one belt of the formation, obeying the flexures of the mountain, sweeps round the margin of the valley, termed the Dutch corner, and continues its course thence along the western base of Evitt's mountain, (the prolongation of Dunning's mountain,) to the Maryland State line. The other belt passes on towards the south-west, or if interrupted, it is only for a short distance, and encounters the northern end of Wills' mountain. In virtue of the anticlinal structure of that ridge, the belt is here divided into two, one taking the eastern base of the mountain along the Cumberland valley, the other the western base, following the valley of Wills' creek. Both of these tracts of formation V,

cross the Potomac into Virginia, whence they are prolonged more than one hundred miles in connexion with the same great anticlinal axis. From information derived from the State Geologist of Virginia, Professor WILLIAM B. ROGERS, the same valuable fossiliferous iron ore, which imparts such interest to this formation in Pennsylvania, still accompanies the stratum, being met with in beds from six to eighteen inches in thickness, and of very pure composition.

As an evidence of the probable continuousness of the ore throughout the long tract between the Susquehanna and the Potomac just traced, it is proper to mention that a bed of sufficient thickness for valuable purposes occurs in Dutch corner, and one has likewise been found near Frankstown, where the ore is used, making a very excellent iron.

Commencing at our former point of departure, at the eastern termination of Bald Eagle mountain, on the Susquehanna, we may trace the formation in a very irregular and winding tract south-east of that already described. This belt extends from the river, with a south-eastern dip, along the south branch of the Bald Eagle mountain, to the head of White Deer mountain. Folding back, it doubles round the end of this mountain axis near Watsonburg, entering Buffalo valley, over the surface of which it expands itself as previously described. The lower beds of the stratum take a winding course round the margin of the valley, running up a short distance into the valleys which head between the several anticlinal ridges that project themselves forward into the main valley, and doubling round these, where they die away upon the plain. Following this curving course, these rocks reach the head of Buffalo valley, whence we may trace them eastwardly by the valley of Penn's creek, with a north dip resting against the base of Jack's mountain. Sweeping round the eastern end of that mountain, they assume a change in their dip to the south, conforming to the axis of elevation in the middle of that ridge. The belt next runs south-westward along the south-eastern foot of Jack's mountain, obeying the gradual flexure of the ridge until it reaches its southern extremity in Huntingdon county. This mountain containing an anticlinal axis at its south-western end, as it does at its other extremity in Union county, the overlying stratum, formation V, mantles round the terminating knob, as it must round that of every similar anticlinal ridge, composed of formation IV, and taking an altered dip to the north-west, it follows the western flank of the mountain, and its continuation, Stone mountain, to the head of Stone valley. The

border of this valley being diversified towards its upper end, by several mountain knobs protruding themselves into it from the north-east, these short and rapidly subsiding ridges, as we have already beheld in a strictly analogous case in Buffalo valley, deflect the course of the formation which runs invariably along their base, and give it a rather winding course, causing it to fold round their points and to re-enter between them, until we reach the south-eastern base of Tussey's mountain. Resting against that flank of this bold ridge, with a rather gentle south-eastern dip, we may trace the formation westward to the Little Juniata, where it is finely exposed, and follow it thence along the eastern base of the same mountain, through Hartslog and Woodcock valleys, and the same regular line of valleys prolonged to Maryland.

In several parts of this long and crooked belt, the fossiliferous iron ore has been already met with in bands having a thickness and a purity of composition, such as to awaken cheering anticipations concerning the general productiveness of the formation in regard to ore. Thus it has been found near Drake's ferry at the base of Jack's mountain on the Juniata, where it displays uncommon purity, and it has been rather extensively developed in Woodcock valley, in three parallel and contiguous beds, when, by the enterprise and knowledge of George Thompson, Esq. it was applied several years ago in making iron, and is much used in some of the neighboring furnaces.

Another long and narrow tract of formation V, lying to the south-east of the former, commences at the Susquehanna at Selinsgrove. Extending thence towards the south-west, its lower beds gradually rise as we advance, in consequence of an anticlinal axis which we can follow into the end of Shade mountain. At this point the belt of formation V divides one branch with a north-west dip, keeping the north-western foot of that mountain, to Lewistown, where, after doubling round the end of the mountain, and entering the long narrows of the Juniata, it resumes its south-westerly direction along the flank and base of the mountain, which here takes the appellation of the Blue Ridge. Passing a few miles beyond the southern termination of this ridge, nearly to Shirleysburg, it is again deflected somewhat to the east; for the strata suddenly, as in all cases when opposite the end of a mountain of anticlinal structure, change their course and run north-eastward some distance into Sugar valley, their dip here being to the south-east. In that valley the formations lie in a synclinal trough, resting between the Blue Ridge and Black Log mountain, along the

western base of which last, the strata stretch forward once more towards the south, with a western dip as far as the southern termination of the mountain. At this point, when the dying out of the anticlinal axis, which has brought up the limestone, formation II, in Black Log valley, has brought together the Black Log and Shade mountains, the ore-bearing stratum, formation V, folds as usual round the end of the knob, and taking a north-eastward course, ranges along the base of the Shade mountain, to where it ends at Licking creek. Folding in an anticlinal axis over the point of this ridge, it changes, of course, its previous south-east dip to a north-western one, and ascends the valley of Licking Creek for a few miles in the form of a synclinal trough, where it pursues its former direction, dipping once more to the south-east and conforming in its course to the south-eastern base of the northern Shade mountain, until it leads us eastward beyond the end of this mountain, to our original point of departure at Selinsgrove.

In many parts of its course, this double belt of formation V gives indications of containing the ore, in bands of sufficient magnitude, to inspire the hope that a minute and systematic survey of the stratum, may disclose it in valuable qualities. At the eastern termination of the Long narrows of the Juniata, where the beds of this rock rests at a high inclination against the foot of the Shade mountain, a seam of the fossiliferous iron ore has been detected of a thickness and quality, nearly if not quite adequate to render it highly useful.

The beautiful and rather fertile little oval valley in the southern part of Bedford county, near Hancock, called Pigeon cove, is based upon formation V, being encompassed on all sides by a belt of hills, containing the fossiliferous limestone, formation VI, and the sandstone, formation VII; but whether the rather flat, anticlinal axis which has upraised the red and variegated shales of formation V, has also brought up to the surface, that part of the formation in which the fossiliferous ore ought to occur, is a point demanding further research. The axis of elevation in Pigeon cove, is almost precisely in the prolongation of the extensive anticlinal line, which upheaves the limestone, formation II, in Black Log valley. They may be traced almost continuously into each other, by observing the dip of the strata. The next important range of formation V, extending through our district, commences at the west side of the Susquehanna, nearly opposite Georgetown, and runs through Pfouts' valley, to where it

divides into two belts, at the eastern end of Tuscarora mountain. Here the anticlinal axis of that ridge has protruded the rocks of formation IV, which form the mass of the mountain. After separating at this point, which is a few miles east of the Juniata river, one belt pursues its course to the south-west along the north-western flank and base of the Tuscarora mountain, the curvatures of which it follows as far as Sidney knob, in Bedford county. On the western side of that ridge the formation disappears in consequence of an enormous dislocation of the strata, which, commencing in this vicinity, runs southward along the western foot of Scrub ridge, tilting its strata and those of the adjacent side of the M'Connelstown cove, (composing formations III and II,) which it borders, into an inverted position and burying the rocks of our formation V, and also the overlying formations VI, VII, and VIII, so that the strata of formation IV, actually lean in some places upon those of formation IX. This has thrown down the ore-bearing shales of formation V, to a depth of probably not less than three thousand feet below the surface, which they would otherwise occupy.

Further to the south, in the neighborhood of Hanover furnace, the dislocation seems to become less and these rocks once more emerge to the surface, forming a narrow belt in which their strata are greatly crushed. This, however, after a course of a few miles, crosses the State line, and finally, the Potomac river below Hancock.

The other belt of formation V, taking the south-eastern side of the Tuscarora mountain, ranges with south-eastern dips along its base, through Raccoon valley, and in the same general course, follows the mountain nearly to the line of Perry and Franklin counties. There the stratum is caused to curve much about, sweeping round the points of the high ridges in that part of Perry and winding into the short valleys between these knobs. It then stretches eastward until it nearly reaches the town of Bloomfield, and thence ranges south-westward, meeting finally, after several meanderings, the northern base of the Kittatinny or Blue mountain, near Wagner's gap. From the latter point it follows the northern slope of this mountain, to the Susquehanna, whence it ranges north eastward as described in my last annual report, resting at the base of that ridge until it leaves the State, near the Water Gap of the Delaware river. Fragments of iron ore, indicating the probable existence of the fossiliferous band, were picked up at several points when making the reconnoissance of

Perry county, but in the belt which stretches from the Susquehanna to the Delaware, along the base of the Kittatinny mountain, notwithstanding a diligent examination has been made, no symptoms of its presence in any quantity have been discovered. Its absence from this, which is the most south-eastern tract of the formation, is probably attributable to the almost total deficiency of the variegated calcareous and fossiliferous layers in the middle of the stratum, with which the ore would appear to be invariably connected.

The only other exposure of formation V, in the State, is upon Montour's ridge, and here the fossiliferous ore is largely developed and at present somewhat extensively worked. A general account of it, sufficient for the present purpose, was offered in my last report. In closing this chapter upon the third Geological district of the State, I would observe that the reader is by no means to infer that the formation thus extensively distributed, and which I have approximately traced, is the only one besides the great blue limestone, formation II, that holds out a promise of containing iron ore in sufficient deposits to warrant a minute exploration. Valuable ores peculiar to each stratum, are often found and occur sometimes rather abundantly, in connexion with formations VI, VII, VIII, IX, and XI, and with the coal measures of Broadtop mountain, embraced within this district. By following up the detailed investigation of all the strata of the region upon the plan already commenced, we hope ultimately to offer to the manufacturers some valuable facts concerning the best clue to the position of these ores. General practical rules in relation to the distribution of so important a mineral if discoverable, are of inestimably greater benefit to the public, than almost any number of merely insulated discoveries, and that they are often attainable by the aid of careful observation and science, must be conceded by every one at all experienced in mining and Geological research.

CHAPTER III.

A GENERAL SKETCH OF THE OPERATIONS OF THE SURVEY IN THE DISTRICTS NORTH AND WEST OF THE ALLEGHENY MOUNTAIN.

SECTION 1.

That part of Pennsylvania which lies to the north and west of the Allegheny mountain, comprising about one half of its territory, exhibits a remarkable contrast to the Appalachian chain which I have been last describing, both in respect to its Geology and its Topographical structure. The strata of its rolling surface belong only to the four or five uppermost formations of our great lower secondary series, whereas, in the Appalachian region, we are presented with every rock of the entire group, from formation I, to the coal measures or formation XIII, inclusive. Here those two great natural agents which have given to every part of our country, all that is peculiar to it in its external Geological and Geographical features—I mean the subterranean forces and the superficial ones—has evidently operated with far less intensity than in the disturbed mountain chain which borders this region on the south-east. In the country which I am now about to describe, the inclination of the rocks is much less, and the changes in the direction of the dip more rare; in other words, the antichlinal axes are flatter, fewer and wider apart, though they preserve their general parallelism. The operation of currents upon the strata would also appear to have been more gentle and evenly diffused, and individual strata have been preserved from destruction, and keep their position near the surface over far wider areas, than in the other region, so that whatever useful mineral deposits they may contain, such as beds of ore or seams of coal, will be found spread out over an extent of country so great, as hardly to be credited, unless we advert to the causes which have occasioned their being thus diffused. One of the most fortunate circumstances for the resources of this portion of the State, arising out of its peculiar Geological structure, is to be found in the universally rolling outline of its surface, which is every where trenched by ravines, and by more or less deep valleys, the results of an extensive denudation by water. This feature gives

us ready access to the strata and all their contents, which lie above the lowest water level of the country, imparting superior exactness to our explorations by the facility afforded for inspecting and measuring all the beds. In entering upon a brief, general description of the mode in which the mineral wealth of this part of our state is diffused, a hasty outline of its leading Geological features will prove a useful introduction to the details which are next to follow.

Taking a comprehensive view of its stratification, the whole of this north-western half of the State has the structure of an extensive basin, or more properly it is the termination of a more enormous basin, which stretches south-westwardly from Pennsylvania to the northern border of the state of Alabama. From the southern boundary of the State, in Somerset county, to the North Branch of the Susquehanna, in Luzerne, the south-eastern base of the Allegheny mountain constitutes a remarkably well defined margin, separating this region from the Appalachian chain. Between that limit and the shore of Lake Erie, on the north-west, and the state of New York, upon the north, the strata all belong to formations VIII, IX, X, XI, XII and the coal measures or formation XIII. The two lowest of these rocks, formations VIII and IX, ranging along the south western foot of the Allegheny mountain, between the points already designated, sweep in a wide curve round the eastern terminations of the upper rocks in Susquehanna and Bradford counties, and are traced westward in a long belt, parallel with the northern line of the State, from Towanda to the state of Ohio. Immediately within the long zone thus delineated, we perceive a bold escapement formed by the hard sandstone strata of formations X and XII, being the actual margin of the great bituminous coal basin.

On the south-east this escapement is the ridge of the Allegheny mountain, but on the north it is a more undulating chain, of more broken outline, which stretches from Towanda, almost due westward by Blossburg, Smethport and Warren, and thence with a greatly reduced height, is deflected somewhat to the south by Meadville and Greenville, until it crosses into Ohio. Along the northern side of the basin, from formation VIII upwards in the series to the coal measures inclusive, the strata have a gentle dip towards the south, leading us into higher and higher beds of rocks, as we recede in that direction from the New York line, where the slate and argillaceous sandstones of formation VIII, form the predominant rocks. In

Crawford and Mercer counties, where the lower strata lie to the north-west of the coal, the prevailing dip of all the rocks of the series is towards the south-east, but along the Allegheny mountain, or on the south-eastern margin, their prevailing inclination is either north-westward or northward, being thus in every case inwards, as respects the central portion of the great trough enclosing the coal. But while this, as a general rule, holds strictly true of the strata along the edges of the basin, it is necessary that we should observe, that within this boundary there exists a number of anticlinal axes, some of them of great length and elevation, others low and insignificant, which give to the strata throughout nearly the entire region, an almost endless succession of more or less gentle undulations. As those axes of elevation have lifted the formations that lie below the coal to the surface, even causing the latter to be swept away entirely, over many considerable tracts of country, and as they in fact divide the whole region into a series of insulated and subordinate coal basins, the exact limits of which it is important I should mention, I shall briefly describe the position and range of such of those as our researches have brought to light, specifying some details about the strata in the several basins which they enclose.

SECTION 2.

Of the fourth district, embracing the country included between the base of the Allegheny mountain and Chesnut Ridge.

Nearly all of the anticlinal axes which are of sufficient magnitude to impress decided features on the topography of the region, or to have caused the removal of the coal measures from along this line, range in a north-east and south-west direction, or in lines parallel to the course of the Allegheny mountain, and are embraced within a belt of country rarely exceeding forty miles in width, measured north-westward from the base of that escarpment.

Beginning with the southern end of this belt, where these anticlinal axes, and their included troughs containing the coal measures are best defined, and where our explorations as far as relates to the south-eastern counties of the great coal field, have been more detailed than

further north, the anticlinal axis which first meets our attention, west of the eastern margin of the coal, is one which occurs midway between the Savage and the main Allegheny mountain in the south-east corner of Somerset county. This is probably a prolongation of that which ranges along the summit of Chesnut ridge, in Bedford county, where it has brought to the surface the limestone and sandstone formations, VI and VII. As it ranges towards the south-west, it exposes the rocks of formation VIII, which form a long wedge-shaped belt, ending near the line of Southampton township. From this point, where the belts of formation IX, on each side of it, have coalesced into one, this latter stratum alone occupies the depression between the two mountains above named, a less extensive denudation of the rocks which fold over the axis, having taken place towards the south of the two separated edges of the higher formation X, which forms the ridges of the great Allegheny and Savage mountains. These unite, and as we approach the Potomac, they compose but one mountain, along whose summit we may still trace the prolongation of this anticlinal axis. It is this axis of elevation which, together with that of Wills' creek mountain, (the westernmost of those in the Appalachian region, to the east,) forms the highly interesting and important coal basin of the Potomac. This basin, commencing towards the head of Stone run, in Hardy county, Virginia, ranging through Maryland and terminating at Wills' creek, in our own State, is here bounded on the east by the little Allegheny, and on the south-west by the Savage mountain. The Pennsylvanian portion of this basin may be estimated at five miles in width, measured along the State line, and seven in length. It is believed that no coal will be discovered to the north-east of Wills' creek, as from the close approximation of the bounding ridges, the coal measures have there been much exposed to denudation and carried off. Of the coal veins enclosed within this trough, the highest in the series is that which is principally worked. It extends with a very undulating line of outcrop near the summit of a long irregular ridge of considerable elevation, lying about midway between the little Allegheny and Savage mountains. Numerous transverse valleys of denudation intersecting the ridge, have interrupted the regular range of this upper coal seam, rendering it difficult to compute the area which it actually occupies, but favoring greatly the operations of the miner, by exposing a more extensive out crop. Its average thickness, as ascertained in numerous places

where it has been opened, is about eight feet, the most extensive mine being that of David Hoyman, about a mile north-east of Jennings's run.

The identity of this with the great seam worked at Frostburg, in Maryland, is highly probable, as well from the character of the coal itself and the accompanying shales, as from the similarity of its position upon the ridge. Several other good seams are known, situated lower in the series, in thickness from three to five feet, but being less accessible and important than the one above, and there being at present but a small demand for coal in this neighborhood except for local use, they have excited but little attention. Iron ore of excellent quality was collected by us on the surface, at many points in the basin, and there is reason to believe will be found in ample quantities especially associated with the shales of the lower seams, whenever the proprietors of the soil shall deem it of sufficient consequence to undertake the requisite diggings. Between the coal seams there occur two or more thin bands of limestone sufficiently abundant to use as a flux or for agricultural purposes. The tract included between the Savage and Allegheny mountains, containing formations VIII and IX, thrown up by the anticlinal axis previously traced, presents but little that is interesting in regard to its mineral resources. The rocks of the Allegheny mountain thrown into north-west dips by this axis, are thus made to constitute the south-eastern margin of another basin, whose north-west boundary is defined by the rocks of the Negro mountain, which have received a contrary dip to the south-east, by an axis passing through the centre of that ridge. The broad and flattened axis of Negro mountain, exposing formation X on its summit and over its gently inclined flanks, is prolonged to the north-east, at least as far as the Bedford and Stoyetown turnpike. Along this elevated belt, therefore, the coal-bearing rocks have been removed, and at the same time the influence of this axis, by elevating the strata in the middle of what would have been a broad and deep basin, between the Allegheny mountain and Laurel hill, has rendered the two minor basins into which it has divided that space comparatively shallow, and removed much coal.

A tract of rather low ground follows the north-western base of the Allegheny mountain, in the southern part of Somerset county, from which the coal measures appear to have been removed by denudation, but the coal almost invariably occurs in the first range of hills further

towards the centre of the basin. Thus in the vicinity of Salisbury, little or no coal is indicated between the mountain and Castleman's river, while it is abundant in the higher lands to the west of that stream. In this neighborhood, as in the south-east basin before described, the best developed coal seam is the large one, being here from eight to nine feet in thickness. Though traceable over a considerable extent of country, it has hitherto been opened in only a few places, there existing at present but little inducement for mining the coal, secluded as it now is from market. The lower and thinner coal beds, and the iron ore often associated with them, have therefore been still less sought for, and are scarcely known. Advancing northward to the neighborhood of Berlin, we there no longer meet with the upper or larger seam, a deeper denudation of the strata having washed it away, but the lower seams have been wrought near the town to some extent, for the supply of Berlin and Somerset. At this place the seams which are mined are three in number, the uppermost affording about five feet of true coal, the middle one, considered the best and hence most worked, about four feet, and the lower one, recently opened, about three feet. The space between the upper and middle beds measures about sixty feet, that between the middle and lower beds from forty to fifty feet.

In some of these shales between the coal seams, occur thin flaggy bands of *iron ore* of considerable purity, being an argillaceous proto-carbonate of iron. There likewise exists a bed of limestone nearly three feet in thickness. Iron ore prevails about Elk Lick creek, near Castleman's river, and may be observed in many places along the north-western declivity of the Allegheny mountain.

Near the base of the same ridge, bog ore may also be frequently found, but the deposits rarely give evidence of a large supply. The occurrence of one or more layers of limestone in the strata between the lower coal seams, is an usual feature in nearly every part of this basin, and from the inestimable value of lime in agriculture, it is to be regretted that more frequent use of it is not made.

Between the north-western slope of the Negro mountain, and the south-eastern slope of Laurel Hill, occurs the next trough of coal measures. These upper strata dip gently to the north-west, from the former of these ridges, and at about the same inclination to the south-west from the latter, conferring upon the valley between them, the structure of a regular synclinal basin, of rather wider and deeper

dimensions, as respects the coal containing rocks, than that embraced by the Negro and Allegheny mountains.

The townships of Addison and Turkey Foot, lying within this trough, have a rough and hilly surface, intersected by streams, which run in deep gorges between the hills. Towards the centre of the basin, the seams of coal usually occupy a low position, being rarely exposed, but in the deep ravines and near the borders of the streams, a coal seam six feet in thickness, is found low down on the banks of the Youghiogheny, near Smithfield, from which a considerable quantity of coal is derived for the supply of that town.

The exact position of this bed in the series and the relative situation therefore of the other seams to it, has not yet been ascertained in this neighborhood, but further research, it is hoped, will make these matters clear. Iron ore exists in many places within this basin, and could probably be procured in ample supplies, for the manufacture of the metal, especially towards either border of the district, if those who are interested would embark in some systematic diggings, among the slates connected with the lower coal seams. About Drake's run, and from thence towards the head of Laurel Hill creek, it would appear to prevail in great abundance, and much of it to be of excellent quality, but occurring in a wild and uninhabited region, it has been but little sought after. Near the head of Garey's run, it is procured for the use of Rogers' furnace, to which it is taken to the western side of Laurel Hill. Exploring the country northward towards Milford and Somerset, we find coal abundant in the hills lying west of Castleman's river, but extending our researches still further north, we observe the surface of the country gradually to rise and to be less intersected by the valleys and ravines, so essential to the full exposure of the strata, and as a consequence, the indications of coal become more rare. Between Somerset and the base of Laurel Hill, very little coal can be detected, though the probability, if we judge from the dipping of rocks and other indications, is great, that the main coal seams have not been washed away, but lie buried beneath the more unproductive strata that occur near the surface. The same remarks are true of the country north of Somerset, until we descend to a considerably lower level along the waters of Stony creek and Quemahoning, where we again find the coal. In this position, it occurs near Stoystown, and further westward, and also eastward on the other side of the prolongation of the Negro mountain axis, which is here

greatly reduced, or possibly, entirely flattened down; and again, on the flank of the Allegheny mountain, at Staller's, on the Bedford and Stoystown turnpike. This vanishing of the Negro mountain axis, causes the whole valley between the Allegheny mountain and Laurel hill, to have the structure of a single basin, and from Stoystown northward, I shall speak of it as one. Iron ore, apparently of fine quality, is found along Stony creek, above Stoystown, and also in many places near the foot of Laurel hill, on the head branches of Quemahoning. That at the old Shade furnace is rough and sandy. This furnace has not been in blast for some years. From the vicinity of the turnpike above spoken of, north-eastward to the Conemaugh, the country is rugged and unsettled, except in a few spots in the neighborhood of Paint creek. Near the mouth of that stream, and along the valley of Stony creek, where some population prevails, the beds of coal are again recognized and have been partially mined at a few points, to supply the blacksmiths and others in the district. The digging of the coal being performed, as in most other similar places, during the winter, and carried on upon a very small scale, the spring thaws cause the earth and slates to fall, rendering the entrance to the mines inaccessible during the summer. We are hence, too frequently precluded from ascertaining the thickness, quality and aspect of the seams, and from procuring those other data, so essential to any attempt to trace and develop the coal over the circumjacent country.

The deep valley of the Conemaugh, exposing the strata from the uppermost beds of the coal series, in this part of the basin downward to nearly the bottom beds of formation XI, we are enabled, through a careful examination of the denuded beds, to determine with some accuracy, the contents of the coal formation in this portion of its range. The artificial excavations along the line of the Portage rail road furnish, from point to point, displays of the stratification, which greatly assist the investigation. Using the facilities thus afforded, we collected an ample suite of specimens from the strata composing the coal measures, together with a set from the underlying beds of all the formations, included between the base of the Allegheny mountain and the first bed of coal. Minute measurements were at the same time instituted, which will enable us to approximate to the thickness of all the strata, between the foot of the mountain and the third principal coal seam, which rests upon its summit. The same was

done in the gap at Laurel hill, where the Conemaugh, passing through that ridge, presents an excellent opportunity for collecting those details of the stratification, which, when applied to other neighborhoods, where the rocks are more obscurely discovered, greatly assist us in tracing any valuable beds which they may contain.

In the vicinity of Johnstown, there are known at present, three seams of coal, the lowest occurring only a few feet above the level of the Conemaugh. The next is between forty and fifty feet higher in the strata, and has immediately beneath it a stratum of limestone, varying from three to eight feet in thickness. Between sixty and seventy feet above the middle coal bed is another, apparently the uppermost workable seam in this vicinity. These coal beds are respectively three, three and a half and four feet in thickness. They are but little worked, supplying only the immediate neighborhood. The mines adjoining the rail road on the Allegheny mountain, furnish fuel to the stationary engines at the inclined planes, and supply a moderate demand from the country east of the mountain. The measurements and other researches undertaken, indicate that most, if not all these mines near the rail road, are in the uppermost of the three seams already mentioned, excepting the mine of Dr. Shoenberger, near the foot of Plane No. 6, on the eastern descent of the mountain, which would appear to be in the lowermost bed in the series.

Passing from the valley of the Conemaugh towards Ebensburg, the surface of the country rises rapidly, and the principal coal seams are again lost to view, beneath the unproductive superincumbent strata, which here spread themselves over the surface. Some small beds from one to two feet in thickness, are however met with. Towards the eastern and western borders of the basin near the base of the Allegheny mountain and of Laurel hill, the lower and thicker beds occasionally show themselves, and admit of being extensively traced.

Among the slates included between these seams, we find as usual, the chief deposits of argillaceous iron ore, the display of which is particularly promising along Laurel run and Hengston's run, which flow southward into the Conemaugh, near the foot of Laurel hill. Ore is also to be found along the waters of Clearfield creek, and in other places, near the western slope of the Allegheny mountain, between eight and ten miles south-east of Loretto.

Northward from Ebensburg, the country descending in virtue of the drainage towards the Susquehanna, we once more cross the outcrop of the coal, though in this truly wild forest region, but very little excavation has been attempted. The Laurel hill loses its features as a distinct ridge, a little south of Blacklick creek, the anticlinal axis to which it owes its elevation and structure, being hardly discernable in the deep gorge through which this stream flows across its termination. Some miles south of this point, the height of the ridge being much reduced and its axis greatly flattened down, the coal slates and the coal itself reach high up on the irregular but gentle slope of the hill. At the extremity of the ridge, coal is found in abundance exposed in the valley of Blacklick creek, whence it is taken chiefly to the town of Ebensburg. Iron ore also occurs, and a considerable amount of excavation has been made in search of it, on the north bank of the same stream, through the enterprise of Messrs. Lewis and Rogers of that town, and with encouraging prospects. About two miles lower down the stream, borings were made some years ago into the strata and salt water obtained, but the manufacture of salt was abandoned. Recently, operations in this place have been recommenced, by Judge Murray, of Cambria county, whose workmen, during the autumn, were engaged in increasing the depth of the wells.

The next coal basin of which I propose to offer a brief sketch, is the long synclinal valley, enclosed by Laurel hill on the south-east, and Chesnut ridge on the north-west. A straight and very regular anticlinal axis, extending along the centre of each of those important ridges, the rocks on the north-western side of the Laurel hill are made to dip towards the north-west, while the same strata appearing along the south-eastern base of Chesnut ridge, incline in the contrary direction, or towards the south-east, giving to the whole belt the structure of a regular trough. To this feature, we owe the preservation of the upper or coal bearing rocks, which have been swept entirely away, from the denuded flanks and summits of the two bounding ridges. It may be well to mention in this place, that a singular degree of confusion prevails in regard to the name of these ridges. From its north-eastern termination, to the break or notch by which the Youghiogheny passes through it, the western ridge is every where styled the Chesnut ridge, but from that point south-westward into Virginia it often, though incorrectly, receives the name of Laurel hill. In my descriptions, I shall apply the name of

Chesnut ridge to this axis throughout its entire length, and reserve that of Laurel hill for the mountain which ranges parallel with it on the south-east, at an average distance of twelve miles.

In the western corner of this coal basin, included between these ridges and bounded by the State line and the National road, some of the coal seams show themselves, being mined in a few places on a small scale, for fuel for the blacksmiths. On the bank of Sandy run, a little north of Elliott's mill, there occurs a natural exposure of iron ore, which, from the apparent quantity of the mineral, deserves attention. The eastern side of the valley, towards the base of the broad flattened ridge of Laurel hill, comprises a wild, barren country of sandy hills and swampy glades, offering nearly insuperable impediments to Geological explorations. Near the eastern base of Chesnut ridge, about a mile and a half south of the National road, on a tributary of the Sandy run, there exists a quantity of good iron ore. It has been extensively explored by Andrew Stewart, Esq., who has lately erected a furnace for smelting it. A little north of the National road in the same range, ore is extensively dug, being transported across the mountain, to be smelted in Huston's furnace, near Uniontown. Between the National road and the Youghiogheny, the country is generally covered with forest and is very rough and wild, becoming towards the river exceedingly broken and hilly.—Seams of coal and layers of iron ore, are here found. The ore is used in two or three furnaces in the neighborhood of Laurel run on the south, and of Sapliek creek on the north of the Youghiogheny. Other furnaces formerly in operation here, and to the north towards Ligonier and Laughlinstown, are no longer in action. On a range of hills, situated about midway between the bases of Laurel hill and Chesnut ridge, north of Ligonier, a valuable seam of coal usually nearly seven feet in thickness has been opened in many places, and may be extensively traced; its position in the strata is evidently higher than the seams commonly met with, near the bottom of the series, which measure respectively about three, four and five feet. As it produces coal of a superior quality, the thinner beds are in this neighborhood almost wholly neglected. It follows nearly the summit of the ridge, which ranges along the centre of the valley from Ligonier to Fairfield, to within almost three miles of the Cone-maugh. Beyond this point, the large bed is no longer to be met with, the denudation of the upper strata between this and the valley of the river, having left only the lowest portions of the coal series.

A valuable iron ore, belonging to the lowest strata of the coal measures, occurs east of Fairfield, on the western slope of Laurel hill, and has long been worked at Ross furnace in the neighborhood. A little below the thick upper coal seam, which lies between Ligonier and Fairfield, there lies a very useful bed of *limestone*, varying in thickness from three to four and a half feet. It is much less impure than that which generally occurs between the coal beds in this region, and therefore yields a better and whiter lime. Near Lockport, and at other places along the deep valley of the Conemaugh, the lower seams of coal are exposed, and if an extensive demand for coal were ever to arise, they would offer great facilities for mining operations. Extending our explorations northward, along the middle of the valley, we find ourselves again above the lower coal seams, in the neighborhood of Armagh, but they rise to the surface and finally crop out and disappear, as we draw near to the base of either of the ridges which bound the basin. This remark holds good as far north as the tributaries of Yellow and Two Lick creeks, the channels of which, lying in deeply denuded ravines, the lower coal seams are frequently exposed along their banks.

This brings us to the northern termination of Chesnut ridge, which grows very irregular and depressed near Yellow creek. North of the turnpike, between Ebensburg and Indiana, neither the ridge nor its anticlinal axis are any longer perceptible. No valuable beds of coal occur near the town of Indiana, which lies too high for the lower seams, which are exposed in the ravines of Two Lick and Yellow creeks, from four to six miles east and south-east of the town. On Yellow creek near the north-west foot of Chesnut ridge, in the slate above a neglected coal drift, there was found a deposit of iron ore, which would justify more careful examination by digging, being only partially exposed in the bed of a little stream. About five miles northward from Indiana, on a branch of Crooked creek, we find a seam of coal, the position of which in the strata is certainly higher than that of the seams on Yellow and Two Lick creeks. Its thickness is sometimes stated to be seven and a half feet, though it yields only about six and a half feet of coal, the seam being separated into two portions by a band of slate thirteen inches thick, the lower mass of coal being four feet, and the upper two and a half in thickness. Northward towards Mahoning creek, the country is high and rugged, the population more sparse, and the impediments to a minute exploration very considerable. Arriving at Mahoning creek, the seams

of coal again appear adjacent to the stream. At Mr. Bell's, north of the Big Mahoning creek and about a mile north of the Jefferson county line, in a position nearly three hundred feet above the level of the stream, a partial excavation of a seam of coal has been made, in a bed which is possibly the same as that alluded to on Crooked creek. At this place, however, the dividing slate is three feet thick, the upper mass of coal being three feet in thickness, and the underlying one buried at the time under water, by imperfect drainage of the mine, was stated to be at least four feet. Between twenty and thirty feet above this coal bed there exists a stratum of limestone, the thickness of which has not yet been ascertained. The lower seams in Mahoning creek are from three to five in thickness, and yield coal of good quality.

In the neighborhood of Punxatawney, there also occurs a seam of coal which has seven feet of thickness.

The details above presented, will serve to show a remarkable regularity in the position of both the coal and the iron ores throughout, indeed, the whole broad belt of country embraced between the Allegheny mountain and the Chesnut ridge, and from the southern line of the State to the counties of Clearfield and Jefferson. Of the coal, there would appear to be at least three seams of moderate dimensions occurring in the lower part of the series; and at a considerable elevation above these, a bed of considerable size and usually of superior quality. To know which of these we are likely to encounter in any given neighborhood, it is chiefly necessary to attend to the direction in which the rocks incline, and to the relative elevation of the place, compared with some one of the strata adopted as a Geological basis. The more usual positions of the iron ore have been already referred to. It is easy to perceive that from the measurements already executed, and from others to be hereafter undertaken, with a view to exhibit as exactly as possible, the relative situation of the several seams of coal, beds of limestone, and the layers of iron ore, which expand widely under the surface of these basins, the explorations of individuals will be greatly facilitated. It is for the purpose of making the details, which I wish to offer in my final report upon these less known districts of our State as precise and ample as practicable, that I propose to continue to some extent, the investigation of the districts above described, and to place hereafter in some of the wilderness portions of the region, north-west of the Allegheny mountains, a part of the corps supplied with a tent or tents, and with instru-

ments for measuring and with tools for exposing the strata, to the extent at least, which is necessary to enable us to recognize and trace the mineral deposits.

It may be useful to those who are exploring some of the mountainous tracts which lie within the enormous coal field above delineated, and serve to guard them against illusions, if I briefly describe the character and aspect of the three formations which are situated next beneath the coal measures, and which therefore frequently occur in the same tracts of country. Next below the sandstones and shales immediately associated with the seams of coal, we have a formation comprising coarse white and yellowish grey sandstones, occasionally imbedding thin layers of dark carbonaceous shale, and usually containing in its uppermost portion, a heavy stratum of coarse white quartzose conglomerate, the pebbles of which are generally rounded. This last rock, where it exists in the formation, is an admirable and well known guide to the position of the coal, the lowest seam of which will be found most commonly, though not invariably, within one hundred feet perpendicularly above it. But in many districts, not only in the interior of the coal fields, but along the Allegheny mountain, the formation is destitute of this distinguishing stratum, and in such places the knowledge of some other land mark, by which the explorer may at any spot ascertain his position in reference to the rest of the rocks, and especially to the coal, becomes of the highest practical value. Such a land mark is to be found, at least throughout a very wide extent of country, on the south-eastern border of the coal field, but particularly towards the southern side of the State, in the highly characteristic and easily recognized stratum of red shale, which constitutes formation XI, of our series. Fortunately, this stratum is present in many situations where the conglomerate, the distinctive bed of the next overlying formation, is wholly wanting. The neighborhood of Farrandsville, on the West Branch of the Susquehanna, suggests itself as an instance. Here the coal is confined to the summits of the loftiest hills in the vicinity, within about one hundred and fifty feet of whose tops we encounter, though much diminished in thickness, the well marked material of formation XI, the total depth of the stratum being only about twenty-four feet. But between its upper surface and the bottom of the lowest of the coal seams, the distance is not more than eighty-two feet, and it is within this space that the whole of formation XII, as far as it is developed in this neighborhood, is comprised. Occurring as

a fine-grained white sandstone, and being entirely destitute of any layers containing pebbles, it has been frequently confounded, not only here but elsewhere in the State, with the true coal measures that rest above it. The thick series of sandstones and shales which compose formation X, and form the entire mass of these hills down to the level of the Susquehanna, has been also considered as belonging to the proper coal bearing strata. This mistake, which has proved a very pernicious error, has arisen from overlooking the well traced line of separation which nature has drawn between the strata, affording us an unerring guide, in the beds of the red shale formation. This red shale mass, formation XI, though a conspicuous and very thick stratum, where it encircles the mountain ridges which enclose the anthracite coal measures, thins away to extremely diminished size, when we extend our observations as far northward as Lycoming county. From numerous measurements made in a former year and presented in my last annual report, it exhibits perhaps more strikingly, than any other rock of our secondary series, a rapid abatement in thickness, as we pursue it to the north-west. But while it augments to the south-east, it likewise expands, though very gradually, as we trace it south-westward, acquiring as it ranges in that direction, a new and highly valuable layer, consisting of a very thick band of pure limestone, inserted near the bottom of the mass of red shale. The increased thickness of the whole formation and the position of the included stratum of limestone, may be seen in the striking exhibition of the rocks, afforded by the Conemaugh and the cuttings of the Allegheny Portage rail road, where the latter crosses that stream by an interesting viaduct. Still further to the south, the formation contains a bed of calcareous sandstone, and is considerably developed in the Little Allegheny, the Savage, the Great Allegheny, and the Negro mountains, also in Laurel hill and Chesnut ridge, (here erroneously called the Laurel hill.) This calcareous sandstone, which in some places approaches closely to a limestone, is extensively employed as a road stone for McAdamising the National road, and to a partial extent other turnpikes which lie convenient to its outcrop. For this it is admirably adapted. In thickness it varies from thirty to sixty feet. Near the National road it is reddish in the lower layers, and of a light bluish grey in the upper, but as we trace it northward, the reddish bands disappear. In many places in the southern part of the State, this highly calcareous sandstone is overlaid by a limestone a few feet thick, which is an extension apparently of

that above referred to, as seen on the Conemaugh. This limestone is converted into lime, in considerable quantity, at Peck's and Ring-er's, in Addison township, in Somerset county, the lime being much prized, as it greatly exceeds in purity and whiteness, any which is procured from the limestone of the coal measures. Certain bands of this limestone and of the shale contiguous to it, are exceedingly fossiliferous, and as formation XI, to which the rock belongs, presents in scarcely any other district of the State, sufficiently distinct fossil remains, to enable us to institute a comparison between this and the other formations, as to the circumstances under which their strata were deposited, these characteristic relics, are invested with considerable scientific interest.

Having given a general description of formations XII and XI, it remains for me to allude to the formation X. This stratum consists of a thick mass of white, grey and buff colored sandstones, with inter-stratified beds of brown, dark bluish and olive colored slates, among which are occasional bands of dark carbonaceous slate, not unfrequently appealed to as an evidence that the whole is a series of coal measures. This error, so prejudicial by inducing a search for coal in this formation, is apt to receive confirmation in the minds of those who study the mere analogies in the external aspects of the rocks, and neglect the more certain guide afforded by the relative positions of the several strata, inasmuch as they frequently find in some parts of the mass, the impressions of vegetation, or even thin sheets of an inferior species of coal of very limited extent and thickness, such as we often see among the true coal-bearing slates and sandstones. The thickness of formation X is very considerable, being usually several hundred feet. This circumstance, in conjunction with the relative hardness of its strata, contrasted with formations XI and VIII, which adjoin it, has caused it to resist the floods that scooped out the valleys in the softer rocks, and to raise into bold and conspicuous ridges. In consequence of this character, the formation before us constitutes the true border of the great bituminous coal field; at least every where along its south-eastern margin, capping the escarpment of the Allegheny mountain in almost every part of its range, from Maryland to the North Branch. From the same cause, it is exposed in all the axes of elevation which sub-divide the great coal field, in the southern part of the State. Thus it occupies the broad summit of the Negro mountain, near the Maryland line, and forms the top and no inconsiderable portion of the sides of

both the Laurel hill and Chesnut ridge, throughout nearly their entire length. Where these ridges decline towards their extremities, formation X becomes buried under formation XI and formation XII, which there fold over their summits. Where those mountains retain their full height, the two latter strata usually rest upon their flanks. Formation XI, usually containing in these situations valuable deposits of iron ore, at present in much request at the neighboring furnaces, this structure of the ridges just mentioned, imparts much practical importance to their Geology. The systematic investigation of that valuable formation already commenced, will be therefore pursued with as much minuteness as the organization of the Geological survey will authorize.

SECTION 3.

Of the operations of the survey in the fifth district, embracing the country west of Chesnut ridge and the Allegheny river.

Having in the foregoing descriptions, presented as concisely as practicable, a portion of the observations made in the exploration of the country between the base of the Allegheny mountain and the summit of Chesnut ridge, and having reserved for my final report the chief body of the more minute and local details, together with the results of instrumental measurements, all of which require to be ultimately accompanied by numerous drawings and a Geological map of the region, before they can be adequately understood, or their practicable importance fully appreciated; I shall in the next place offer a similar general account of the Geological structure and resources of those sections of the State which we have explored, lying west of Chesnut ridge, and also between the Allegheny river and the Ohio State line.

Considering the anticlinal axis of Chesnut ridge, and a range of elevated strata nearly in its north-east prolongation, as the true boundary of the main or north-eastern basin of the whole bituminous coal field of the State, and the low chain of hills capped by the sandstone and conglomerate of formation XII, passing through Mercer, Crawford and Warren counties, as its other margin, (the minor undulations within these limits requiring to be neglected, in a compre-

hensive view,) we shall find proofs of a remarkable degree of uniformity in the strata and their contents over this extensive region, implying a singularly extensive range in many of the principal beds of the formation. The influence of this feature in the Geology, on the early and full developement of the economical resources of the western and north-western counties, it would be difficult to overrate, for the data derived in any one neighborhood from judiciously planned and conducted measurements and observations, become of exceedingly wide application, in leading us to a knowledge of the state of things elsewhere; and if these measurements can be made sufficiently numerous, an amount of accurate knowledge will be furnished, capable in such a region of imparting a high degree of certainty and success to the undertakings of miners and others, who aim at unfolding its mineral wealth, to supply the wants, or add to the comforts of the community.

In presenting a brief description of this western coal basin, I shall commence on the side next the anticlinal axis of Chesnut ridge, and make mention of the various strata in the ascending order, which leads us to the beds of the coal formation, as they cap the surface in the interior of Greene county, and therefore to the uppermost of that vast series of deposits, which I have termed the lower secondary formations of Pennsylvania.

The same order will be observed in speaking of the country included between the Allegheny river and the Ohio State line.

SANDSTONES AND SHALES OF FORMATION X.

The lowest rock which presents itself to our notice in obedience to this plan, is the thick sandstone, formation X, which bounds the basin, ranging in a belt along the summit of Chesnut ridge, where it shows itself in many places, folding with opposite but gentle dips, over the anticlinal axis of that mountain. Where the National road crosses this ridge, we find it in the form of a hard, white, fine-grained sandstone, with a somewhat glazed surface, often thin-bedded in its structure, and much traversed by fissures and irregular joints. It is of considerable thickness, and dips to the west twenty-five degrees north, at an angle of twenty-five degrees. Beneath it there is a thick mass of alternating beds of slaty sandstone, and shale or slate, the former in layers of from one to thirty feet in thickness, being hard, fine-grained and of a grey color; the latter black and yellow, and

sometimes of a feruginous brown color, irregularly laminated, and readily crumbling when exposed to the atmosphere.

On the Loyalhanna, similar sandstones are met with, while on the Conemaugh, above Blairsville, the observer will notice in the same relative situation, a number of alterations of white and grey sandstones, separated by shales.

FOSSILIFEROUS LIMESTONE OF FORMATION XI.

This rock, interposed between the previous sandstones and the overlying red shale to which it belongs, is the best marked, most peculiar and interesting rock of the series composing this mountain range. It can be traced from the Conemaugh to the southern State line, and is found dipping both east and west, or on both sides of the anticlinal axis. It is a siliceous limestone, or a limestone containing a small quantity of pure and well rounded grains of sand, is of fine texture, and of a light blue color, though sometimes its tint is yellowish green. On the National road it is found on the first ridge, and also on the main mountain, in the former case, dipping west fifteen degrees north, at an angle of twenty-five degrees. It lies in layers of from one to ten feet or more in thickness, separated by bands of a calcareous shale. The upper part is remarkably full of fossils, as is also the intervening shale. On the Susquehanna, there are two beds or layers exposed, separated by a thick bed of red and yellow shale, containing a few bands of limestone. The lower bed is a most singular rock, of a light blue color, very hard, and breaks with a semi-conchoidal fracture. It dips nearly due westward, at an angle of ten degrees. Occasionally the yellow color predominates, giving the rock the exact appearance of some varieties of serpentine. When exposed to the water it decomposes, the calcareous matter being washed away, leaving a porous and siliceous crust of an inch or two in thickness, which will not effervesce. This bed measures thirty feet in thickness, being a nearly solid rock, without a seam, the upper one is of a darker color, harder and more fossiliferous, and four feet in thickness. At other points on Chesnut ridge, this rock is met with having a considerable thickness, but no opportunity was there afforded for accurately measuring it.

On the Conemaugh, this stratum is exposed on both sides of the axis, dipping both east and west; it is accompanied with shale of a bright purple color, and appears to be very thick. There is reason

to believe that small quantities of *lead* and *zinc* ore may be detected in the lower beds of this deposit, particularly on Chesnut ridge, where it seems to have reached its greatest developement. Regarding it and the accompanying red and variegated shales, as belonging to formation XI, underlying the western coal measures, the whole group will be seen to be much thicker here than further north-eastward in the State, especially along the Allegheny mountain, while its features are more characteristic. The dark blue bed of limestone, which is full of fossils, usually affords an excellent lime.

RED SHALE OF FORMATION XI.

Overlying the limestone and surmounted in its turn by the sandstone and conglomerate beds of formation XII, occur the beds of variegated shale belonging to formation XI, red, black and yellow, which are much exposed in various places by diggings made in search of ore. At Cool Spring furnace, there are found two thin veins of coal, about one foot thick, beneath the conglomerate. The first dips at an angle of thirty-two degrees, and is imbedded in the shale. Beneath it is a bed of blue ore, a proto-carbonate of iron in three layers, composed of irregular nodules from eight to fifteen inches in diameter. It is not probable that any large deposits of coal will be found in this stratum of shale, inasmuch as the conglomerate beds of formation XII appear, with only few exceptions, to underlie the lowermost workable coal bed in all the coal basins of our state—but as a depository of ore it merits close investigation. This stratum is well exposed on the Loyalhanna near Youngstown, and also on the Cone-maugh above Blairsville. At the former place its beds are red and blue, well laminated and compact, and dip at an angle of ten degrees, nearly due west. The thickness here from approximate measurements, that were made, must be nearly ninety feet. At the latter place it is much thinner, and of a prevailing purple or red color.

SANDSTONE AND CONGLOMERATE OF FORMATION XII.

Running parallel with the preceding and resting upon it, we find, on the western flank of the Chesnut ridge, an important and conspicuous stratum, forming the true margin of all our coal basins. Here it dips towards the west, under the coal measures at the base of the Chesnut ridge. It is a true conglomerate, particularly in the lower part. The pebbles are of white quartz, sometimes disposed in bands,

but at other times forming a very coarse conglomerate, excessively hard, which has a glazed appearance. On the Chesnut ridge, opposite to Uniontown, it is well exposed, its outcrop forming a ledge about thirty feet in height. It dips at an angle of thirty-five degrees, in a direction west, twenty-five degrees north. It must be recollected that only the lower part of this stratum is a true conglomerate, and as we follow it north, this portion of the stratum seems to be less perfectly developed. On the Loyalhanna, where the formation is easily recognized by its position in regard to the fossiliferous limestone, it shows little of the conglomerate character, being a coarse white sandstone. At Mount Pleasant it was not seen in place. Pursuing it towards the south-west, it appears to increase in thickness, until we cross the Virginia line.

FORMATION XIII—COAL MEASURES.

NO. I. COLORED SHALES WITH COAL SIX FEET THICK AND IRON ORE.

At the bottom of the true coal measures, the first distinctly marked sub-division of the strata, is a thick bed of shale. It is generally soft and usually highly colored, being red, black and yellow in various shades. It contains both iron ore and coal. At Cool Spring furnace, ore of good quality has been obtained from it, and Etna furnace, one mile east of Connellsville, is also supplied with ore from the same stratum, which has been worked for twenty years, and gives every indication of containing an almost inexhaustible supply.

At the former place a seam of coal has been opened at several points, and is estimated to be about six feet in thickness. It appears to be of good quality, and lies in the lower part of this shale stratum. It is accompanied by bands of ore. Near Youngmanstown, two and a half miles north of the Loyalhanna, a seam of coal has been opened on the property of W. Johnston, Esq., which, from several features about it, is probably the same with the one above described; if not, it occupies very nearly the same position. It is near the summit of the first or westernmost ridge of the mountain, is six feet thick, and is probably accompanied by ore, although no excavations have been made for that mineral.

This stratum, from its well marked position and valuable contents, is worthy of a detailed examination throughout its whole extent, and in the future operations of the survey, will receive its due proportion of research.

• No. II. WHITE SANDSTONE.

Along the summit of the western ridge of the mountain, called the Chesnut ridge, there can be traced a thick stratum of sandstone, dipping with a regular inclination to the west, twenty-five degrees north. The outcrop of this rock forms, in many places, a steep ledge thirty feet in height. It is a solid and generally fine-grained sandstone, admits of being readily dressed, and splits into well-shaped prismatic blocks. Sometimes it crumbles, on exposure, into a beautiful white sand. The general color of the stratum is yellowish white; it is also seen brown, red, or with spots of a peculiar rosy tinge. The lines indicating the laminae of deposition, are generally very evident, and the lower portions are sometimes a conglomerate in thin and irregular bands. These bands are composed of white quartz pebbles of small size. This stratum, apart from its thickness and extent, is important, as pointing to the principal position of the iron ore so abundantly distributed along this ridge, and which lies chiefly beneath it and above the main conglomerate or formation XII. It is well exposed on Chesnut ridge, opposite to Uniontown; also at other points in the same chain, as at the gap of the Youghiogheny and opposite Mount Pleasant, and on the Loyalhanna, where it abounds in impressions of *lepidodendra*, *sigillaria*, and other plants common in the coal measures.

No. III. SHALE—COAL THREE FEET THICK—IRON ORE.

Overlying the white sandstone, there rests a heavy bed of shale of the variegated appearance, quite usual in the lower shales of this section of the basin, whose thickness, though obviously considerable, was not determined, through want of a favorable place for making the measurement. This shale, like the other similar beds of the mountain, contains coal and ore, but the principal imbedding stratum of the latter mineral, is the shale (No. I.) already mentioned, between the white sandstone ledge and the conglomerate. At Cool Spring furnace, three and a half miles north-east of Uniontown, a coal seam about three feet thick shows itself in this stratum. This has not been mined, but iron ore of good quality has been obtained from the yellow and black shale above it.

No. IV. SANDSTONE.

This stratum in its upper part consists of layers of sandstone separated by shale, which is yellow and black, very soft and full of vegetable impressions. The layers of sandstone are hard and fine-grained, usually from three to six inches in thickness, and gradually become more numerous and close together, as we pass towards the bottom of the mass, until a compact rock presents itself. These thin beds are often broken and contorted in a singular manner.

No. V. SHALE.

Ascending, we pass from the upper layers of the preceding stratum, by a gradual transition into a bed of shale, resembling the shales of the open country, west of the base of the mountain. It is soft and imperfectly laminated, and like the other shales described, of several colors, being brown, black and yellow. Thickness, one hundred feet.

No. VI. SANDSTONE, 100 FEET THICK.

Surmounting the shale just mentioned, in the part of the mountain that lies to the south-west of the Chesnut ridge, (called Laurel hill on the map,) and which is here much elevated, and contains the strata better developed than the north-eastern portion of the ridge, we find a sandstone of some thickness. The rock in the upper part is coarse and brown, that in the lower part occurs in layers very hard and tolerably fine-grained. The thickness of this rock cannot be less than two hundred feet. It was identified only on the south-western section of the Chesnut ridge, where it is inclined at an angle of twenty degrees, dipping nearly due west.

No. VII. SHALE WITH LAYERS OF SANDSTONE—COAL.

The next sub-division of the series is a bed of shale, with layers of sandstone. It appears to be of considerable thickness. These layers, from one to four inches in thickness, consist of a yellow fine-grained sandstone. The shale is yellow and black, constituting the principal part of the bed as far as hitherto determined. At several points along the base of the mountain, there are decided indications of the existence of beds of coal in this stratum; indeed, in a few

places these have been opened. They are unquestionably seams that are situated below the Pittsburg series, rising and cropping out along this line. This part of the country is still so covered with forest, and the excavations are so limited, that it is impossible to see the accompanying strata, and consequently to determine the precise situation of these seams; but there is at present good reason to believe that two of them are contained in this bed of shale and sandstone.

On the farm of Mr. Woods, in Union township, Fayette county, at the base of the mountain, a coal seam is found dipping westward at an angle of eighteen degrees, in apparently the above mentioned sandstone. It is about four feet thick, but the accompanying strata are not discernable, except where the following section is exposed:

Soil,	-	-	-	-	-	2 feet.
Shale, yellow,	-	-	-	-	-	4 "
Coal, impure,	-	-	-	-	-	1 "
Shale, blue and friable,	-	-	-	-	-	2 "
Coal compact,	-	-	-	-	-	4 "

About one hundred yards west of this exposure, on the same ridge, we encounter evidences of another coal seam, which has not yet been opened. About one mile south of this place, a drift has been made into a bed of coal, which we have good grounds for believing is the same as the one here mentioned. This place is just at the foot of the mountain, and on the east side of a low ridge, which shows shale and slaty sandstone dipping west, and overlying the coal. There are also indications of another vein, observing the same distance above the first, as exists between the small seam noticed in the section and its companion.

About one-fourth of a mile west, the *Pittsburg seam* presents itself, exhibiting a noble bed of coal, nine feet in thickness.

In Derry township, Westmoreland county, about three miles north of Youngstown, a seam of coal has been opened on the farm of — Knoll, presenting features which give us reason to believe it to be a continuation of the bed above referred to, as belonging to the present sub-division of the strata. It can be traced for some distance on a low ridge, about one mile from the mountain, and is worked in several drifts. It measures five feet in thickness, yields coal of good quality, and exhibits just over it, layers of shale and slaty sandstone, though imperfectly exposed.

About six miles west of Mount Pleasant, in Westmoreland county, there are numerous salt works on the Big Sewickly creek, which are supplied with fuel from a coal seam, whose presence in this position can only be accounted for by supposing it to be one of the inferior beds thrown up in the line of an anticlinal axis, which passes in this vicinity. This bed is five feet thick, with brown shale above and below it, and is worked for the use of the salt wells and steam mills adjacent. Salt water has been found here at the depth of one hundred and thirty feet. Both to the east and the west, a thicker bed, being the same with the main Pittsburg seam, is extensively mined.

The coal seam, which, for the sake of precision, I denominate the Pittsburg seam, is found about three miles west of the creek, and two and a half miles east of it.

At Middletown, in Fayette county, near the line of the anticlinal axis before mentioned, there is exposed a bed of coal three feet in thickness, at an elevation of about thirty feet above the Red Stone creek. Overlying it, are brown and black shales and a slaty sandstone. Judging from a hasty examination, this bed must lie beneath the Pittsburg strata, and probably be identical with the one above described.

NO. VIII. SANDSTONE.

On the western slope of the hills which we first meet in the ascent of the Chesnut ridge, and which form the first bench or terrace on the flank of the mountain, the only rock seen in place, is a slaty sandstone of a brown color. It is hard and coarse-grained, occurs in layers from six to eight inches thick, which increase in number and thickness towards the lower part of the stratum. It is very indistinctly exposed, being covered with soil, vegetation and the debris from the more elevated rocks of the mountain. This stratum was principally noticed at Uniontown; but in other situations, the rock immediately at the base of the mountain, is so similar to it in many respects, that it is not practicable to distinguish them.

Our principal object in the explorations during the past season, being to ascertain the nature and contents of the strata which compose the valley of the Monongahela, as far eastward as the base of Chesnut ridge, our examinations of the mountain were necessarily very general. From a deficiency of time, which another season will remedy, we were only enabled to investigate minutely a few points,

namely: opposite Uniontown, on the National road, at the gap of the Youghiogheny, opposite Mount Pleasant, on the Loyalhanna, near Youngmanstown, and on the Conemaugh, above Blairsville.

Along the western base of the ridge, the Pittsburg series rises to the surface, the coal No. seen in place on the Allegheny river, being in many places from half a mile to two miles from the mountain. It is by no means easy, however, to distinguish the other strata associated with it. From the Youghiogheny to the State line in a southwestern direction, there may be seen a depression or narrow valley running along the foot of the mountain. Immediately west of this little basin or valley, there rises, displaying along its eastern slope one or two low steps or terraces, a long anticlinal elevation of considerable breadth but no great height. It can be traced north of the Youghiogheny, but in that direction gradually becomes less distinct. This valley was most probably formed originally by the scooping action of the retreating waters, as they precipitated themselves down the western flank of the mountain, rushing with enormous momentum over the soft shales that so largely compose this lower stratum of the coal measures. Its existence, interesting as a subject for geological speculation, is rendered additionally important by the impediments it offers, in the present state of the surface of the country, to our ascertaining all the strata which lie immediately beneath the great Pittsburg coal seam, and which necessarily reach the surface along this belt of country, at the base of the mountain. The foregoing account of this lower part of the series is, however, tolerably complete, and I entertain a confident hope that the explorations of the next season in the same district will leave nothing of practical or scientific interest connected with these rocks undetermined. By employing the more ample data which we are collecting along the western base of Chesnut ridge, to interpret the stratification of the far less distinctly developed basin that lies along the eastern base of the same mountain, we shall be able to clear up much existing obscurity in our knowledge and add materially to the usefulness of future explorations in that quarter.

PITTSBURG SERIES.

Commencing at the level of the Ohio river at Pittsburg, and embracing in the ascending order all the strata, to the uppermost in the series as far as they have yet been identified.

No. 1. RED AND BLUE CALCAREOUS SHALE.

At Pittsburg we find at the base of the hills which overlook the city, a bed of variegated calcareous shale, of a peculiar mottled appearance, its lower portion reaching down nearly, if not quite to the brink of the Ohio river. This shale we make the first in our enumeration of the strata which compose the valley of the Monongahela. At the mouth of Sawmill run, and at several other places in that vicinity, a bed of sandstone is seen just rising above the water level, probably the upper part of a thick deposit; but as it has not yet been observed in other places, and no opportunity for its further examination has been thus far afforded, it is omitted for the present, and considered as belonging to the strata beneath the present series. The shale above mentioned is a bed of considerable thickness; it consists of two varieties, one blue and the other a bright purple or red, irregularly intermixed in spots, blotches and bands. The blue variety lies sometimes in continuous layers. It is soft and calcareous, sometimes without any regular cleavage, and exists throughout as a rather homogeneous mass, very friable and easily crumbled by the weather. Dispersed through it, are numerous calcareo-ferruginous concretions, lying in irregular layers, and occasionally so abundant as to constitute a considerable part of the whole bed. They are of all sizes, more or less ferruginous and excessively hard.—Some minute fossils have been detected in this stratum, but it is generally not fossiliferous. The quantity of calcareous matter diffused through the shale is such, in fact, as to warrant our considering it an impure *marl*. From Pittsburg it may be traced along the western bank of the Allegheny river to some distance above Sharpsburg, rising as it extends northward in conformity with the general slight southwestern dip of the strata. On Thompson's run, a branch of Turtle creek, fourteen miles east of Pittsburg, it is met with at nearly the same elevation as at that city, forming the base of the hills. Being at the bottom of the series as hereabouts exposed, it is only within confined limits, restricted to the lowest parts of the central district of

the coal basin, that this stratum is exhibited. Back from the rivers it conceals itself beneath the hills, and must finally crop out upon the surface (if it does not thin away) towards both the south-eastern and northern sides of the basin, where we hope that extended researches will identify it and trace its position.

No. II. COAL.

Resting on the above, is a thin seam of coal, varying in its thickness from six to eighteen inches, and of good quality, and though a narrow band, ranging over a considerable, perhaps even an extensive area of country. It is hard, black and brilliant. It is well displayed in contact with the preceding stratum at the base of the hills in the immediate vicinity of Pittsburg, and was detected by us also in Indiana township, Allegheny county, and in Franklin township, Westmoreland county. It probably crops out towards the north and east, with the other members of the series, but its thinness renders it difficult to trace it by any indications of its own on the surface. One foot is about its average thickness.

No. III. LIMESTONE.

This is the highest fossiliferous limestone met with, in the Monongahela valley. It is a dark grey or black limestone; when first exposed is extremely hard, effervesces freely when treated with an acid, and is remarkable for the abundance, though not the variety of the fossils diffused through it. These are principally bivalves, species of *productus*, *leptena*, *terebratula*, &c. Joints of *encrini* are also very abundant, from one-sixteenth to one-half an inch in diameter, the column being composed of crystallized carbonate of lime, which has a brilliant appearance when freshly broken. Another very abundant and characteristic fossil is a species of *orthocera*, from one-half to two inches in size, often abundant on the surface of the rock. *Ammonites* have also been found in it. When exposed near the base of the hill, this stratum forms a shelf above the small coal bed; it is of a brownish grey color, and outward slaty structure. If judiciously selected it will make a good lime, and has been used for the purpose on the Mechanics' and Farmers' turnpike at Pittsburg. In company with the preceding strata, it rises to the north along the margin of the Allegheny river. It has been detected by us in Indiana, Wilkins and Versailles townships, Allegheny county, and in

Washington and Unity townships, Westmoreland county, and on the Kiskiminetas, below Saltsburg. Thickness about two feet.

NO. IV. OLIVE SLATE AND BUFF COLORED SHALE.

The next stratum ascending, is a heavy deposit, consisting of shale, passing into slate, with sandstone layers. The lower portion is a soft shale of a drab or yellowish color, regularly laminated, and decomposing into a stiff clay. Nodules or concretions of compact, fine-grained and tolerable pure limestone are dispersed through it. It passes into a heavy slate, of a blue, yellow and black color. It is slightly micaceous, contains a good deal of sand, and splits into plates, somewhat resembling roofing slate. Upon this, in some places, there is a thick bed of slaty sandstone, passing gradually into a smooth slate. The sandstone layers are sometimes very compact and heavy, at others separated by bands of shale. The dark colored portions of the stratum, are generally fine-grained, have a ready cleavage, and contain impressions of plants. Plates may be obtained two feet square, beautifully marked with these remains of an ancient vegetation. These are not found in the hard siliceous upper layers. The whole mass may sometimes be observed, divided in a vertical direction by joints, which separate it into prismatic blocks and impart a picturesque appearance to the exposed portions. Layers of calcareo-ferruginous concretions are found running parallel to the cleavage. They are generally round and rough or knotty on the surface, and from two to four inches in diameter.

The upper part of this bed, immediately beneath the overlying stratum, differs frequently in appearance from the rest. It is much softer, red or yellow in color, and slightly ferruginous. The hard siliceous portions afford an abundant supply of good flagstones. The dark black bands have been mistaken for the soft shale accompanying the coal.

This member of the series may be traced generally along the water courses throughout Allegheny county, and is exposed in Unity and Franklin townships, Westmoreland county, and Connelville township, Fayette county.

Thickness by estimation—one hundred feet.

NO. V. GREY SANDSTONE—BUILDING STONE.

Upon the above, there rests a valuable and important deposit of sandstone. The lower portion is very solid and compact, affording an excellent material for building and differing from the upper, which is generally too slaty and broken to be used for this purpose. The prevailing color is a light grey, with a yellowish tinge; in other places it is brown and brownish green. It varies in composition as much as in color, but generally admits of being easily dressed, and of being readily split into prismatic blocks. Some portions are remarkably micaceous, in others the mica is entirely wanting. Occasionally, it is not fit for masonry, being too friable, and crumbling too freely on exposure to the atmosphere, in consequence, chiefly, of its containing in these cases, a considerable proportion of clay. In this rock, the lines of deposition are very manifest, forming beautiful curves and accurately representing the eddying currents, by which the fine sand was originally deposited. These are most evident, where a brown layer interposes itself in the lighter colored rock.—Imbedded in the lower parts of the mass, are great quantities of pebbles, which differ in color and composition from the material of the surrounding sandstone; they consist, generally, of a drab or a bluish colored clay of a fine texture, and contain minute specks of mica; they are from one to fifteen inches in diameter, but always rounded, and apparently water worn. The question of their origin suggests some interesting enquiries, but I shall for the present waive all matters of mere hypothesis.

The lower part of the stratum contains also thin seams of vegetable remains. These fill the joinings of the layers, and are composed of black carbonized matter, which, in some instances, assume the condition of a pure coal. They are slaty, friable, and emit a bituminous odor, when freshly broken. These impressions are generally so interlaced and compact together, that it is difficult to distinguish their forms; now and then, however, distinct figures are traceable from six to eight inches broad, and also curved stems of considerable thickness.

In many situations, this rock is soft, crumbly and granular, consisting of rounded grains of sand, of a dark green and sometimes a brown color, passing into a ferruginous reddish tint. This change of color depends upon the quantity of iron present in the rock, and

the stage of decomposition to which it has arrived. The grains are of pure white quartz, evidently water-worn and united by a calcareous cement, particularly in the green and brown varieties. In the former, some minute fossil univalve shells have been detected.

This rock is sometimes met with, in a state of complete decomposition in the form of a coarse sand. Certain layers are yellow, others bright red, with intervening layers of gray sandstone, which, by their containing but little iron, have resisted decomposition. In these cases, the thin flakes of the vegetable remains have been replaced by layers of black clay and sand. The rock in this state is too friable to admit of being transported. The upper part of the main stratum into which the preceding passes, is generally very schistose, with irregular laminations, and presents a broken, shattered appearance. It is sometimes very full of nodules, which are chiefly concretions of an impure iron ore. This stratum affords an abundant supply of building stone to the city of Pittsburg. The sandstone employed in the construction of the new Court-house, the Western Penitentiary, and other public buildings, and also some private edifices, belongs to this member of the series. It is quarried in many places on the Monongahela, along whose banks it can readily be traced, until it sinks below the water level of the country, along with the other strata situated below the Pittsburg coal. Medium thickness seventy feet.

NO. VI. SHALE.

This is a bed of red and marly shale, internally blue and mottled, resting on the schistose part of the preceding stratum, and forming in the hill sides a well-defined belt of a bright red or purple color. It is in general imperfectly laminated, slightly calcareous and contains traces of fossil shells. It is not exposed on the hills immediately around Pittsburg, but may be observed on the level, or slightly undulating flat upon which East Liberty is situated. It extends widely through Allegheny county. The thickness averages twelve feet.

NO. VII. SHALE AND SLATY SANDSTONE.

The next, in order, is a thin and inconspicuous bed, yet sufficiently different from the accompanying strata to claim for it a separate recognition. It consists of blue or yellowish green slate,

marked with ferruginous discolorations, and contains layers of sandstone. When these predominate, it is a coarse slaty sandstone. Ten feet.

NO. VIII. LIMESTONE.

This is the first or lowest of the non-fossiliferous beds of limestone beneath the Pittsburg coal seam. It is a well-defined stratum consisting of a hard, yellowish or buff colored limestone, jointed into square blocks. It effervesces freely, gives out an argillaceous odor, and is marked with transparent specks of crystallized carbonate of lime. It probably contains too much oxide of iron and argillaceous matter to yield a good lime. For weight and hardness it is quite remarkable. Although frequently exposed along the hill sides, it is not easy to trace this stratum, as it is very apt to be covered up by the matter from the overlying shales. Thickness three feet.

NO. IX. RED AND BLUE SHALE.

Reposing in immediate contact with the preceding, we observe a bed of red and blue shale, distinguished by its want of tenacity, its bright colors and smooth cleavage. The red and blue portions are irregularly intermixed. This is one of the colored shales which give the red and variegated appearance to the lower part of this series and may be met with on the sides of the hills and ravines, throughout Allegheny and the northern part of Westmoreland counties. Around East Liberty, this and the next stratum are found on the surface of the remarkable flat on which that suburb is situated, in many places decomposed and forming a red soil. Thickness four feet.

NO. X. BUFF COLORED SHALE.

Along the escarpement of the hills where the strata have been laid bare by slides or artificial excavations, we meet with a smooth face of compact and well laminated shale of a light yellow and buff color. This shale so greatly resembles in appearance some of the other beds, that it can only be identified by its relative position to the accompanying strata. The surface is frequently white from infiltrations of carbonate of lime, and in other places is tinged brown with ferruginous stains. Thickness eighteen feet.

No. XI. YELLOW AND PURPLE SHALE.

We have next a bed of variegated shale extending to the bottom of the next limestone. The lower part is frequently of a dark purple color, and is very soft and not well laminated. The prevailing color is yellow. It is frequently exposed on the sides of the runs and water courses. Calcareous nodules are scattered through it, sometimes constituting the largest portion of the stratum. Thickness ten feet.

No. XII. LIMESTONE.

Upon the preceding, is a thin bed of limestone, resembling No. VIII in appearance and composition. Blocks of it are frequently scattered along the base of the hills, having fallen down from the washing away of the underlying bed of shale. Thickness two feet.

No. XIII. RED AND YELLOW SHALE.

The next stratum is a bed of red and yellow shale. It varies much in composition, but preserves its variegated character. It is soft and friable and contains a few calcareous nodules. Thickness twelve feet.

No. XIV. LIMESTONE.

Over this rests a conspicuous and widely expanded bed of limestone of moderate thickness; owing to the presence of the oxide of iron, it is yellow on the surface, though internally its color is dark blue. It breaks off in square or oblong blocks, which are hard and heavy. Portions of it might, perhaps, receive a good polish, and experiments to ascertain this point will be made. By the decomposition of the underlying shales, it is often found tumbled down at the base of the high hills which enclose the Monongahela and Youghiogheny rivers, along whose shores its fragments are frequently abundant. Thickness from three to five feet.

No. XV. SHALE AND SANDSTONE.

Surmounting the last limestone, there occurs a thick and important deposit of shale and sandstone somewhat variable as to its composition, which extends up to the next bed of limestone or that which

underlies the main Pittsburgh coal seam. It may in almost all cases be seen where the coal itself is exposed, generally in the character of a grey slate, well laminated with interspersed sandstone layers, varying from a few inches to several feet in thickness, and separated by soft bands of shale. The upper part of this stratum adjacent to the limestone is frequently very soft and friable, abounding in calcareous nodules, irregularly dispersed throughout the mass. Occasionally, but not very often, the sandstone layers increase in number and thickness, with a corresponding diminution of the shales, giving rise to a sandstone sufficiently compact to be employed in building. It is quarried for this purpose in the vicinity of Pittsburgh, though more usually its principal useful application is in supplying much excellent flagstone, which it readily affords of large size and very smooth surface. This stratum extends through the valley of the Monongahela, from the foot of Chesnut ridge to the western boundary of the State, obeying the general inclination of the accompanying strata, and exposed in corresponding situations. The sandstone layers very frequently exhibit "ripple marks," disposed with great regularity, showing that the rock was deposited from a rather gentle current and probably in a shallow sea. Impressions of arundinaceous plants are not uncommon. Thickness, by estimation, thirty feet.

NO. XVI. LIMESTONE.

Resting on the above, and immediately underlying the Pittsburgh coal seam, is a bed of limestone of characteristic appearance and remarkable for the regularity with which it accompanies the coal. It consists of blue and black limestone in layers from six to ten in number, separated by shale. One of these layers is generally found immediately under the coal seam, succeeded by the principal body of the shale, beneath which are the remaining layers of limestone in a close and continuous stratum. These layers are from one to two and a half feet in thickness and vary in their color, which is generally dark blue, though at other times it is a deep black, in which case the rock is ferruginous, and gives out a bituminous odour. When there is a deficiency of calcareous matter, the upper layer adjacent to the coal seam is wanting, and its place is supplied by a layer of excessively hard calcareous nodules called "nigger heads" by the miners, and which are imbedded in the usually intervening shale. In the northern part of the district this shale is of a light yellow and

brown color, is slightly calcareous and contains some ferruginous concretions. In the eastern part of the district, along the base of Chesnut ridge, it is distinguished as one principal depository of the valuable iron ore for which that belt of country is deservedly noted. Like many of the other strata of the series, it appears to augment in thickness and particularly in its ferruginous character as we advance south and south-east. It is chiefly along the eastern outcrop of the Pittsburg coal seam, that we are to look for valuable deposits of iron ore. Thus, in George and Union townships, in Fayette county, large quantities of admirable ore are obtained from this stratum.

It underlies the coal which is here of increased thickness. The ore is of the variety properly called an argillaceous protocarbonate of iron, distributed in layers throughout the shales. There are three of these layers in close proximity in many places; the first, called the blue stone, is about two feet below the coal and separated from the next, the masses of which are smaller in size, by clay or crumbling shale from one to two feet in thickness. Under this is the third layer or bed, of still smaller nodules, separated from the former by two feet of shale. Ore has been found in this stratum in various neighborhoods.

Instead of the black and crumbling shale dividing the lower layers of limestone, we sometimes witness a layer of coal one foot thick. This is the case at Brownsville and Connellsville. Its true character and composition may be ascertained from a comparison of sections taken near Pittsburg, Canonsburg, Williamsport, Limetown, M'Keesport, Elizabethtown, Brownsville, Connellsville, Blairsville, and other points throughout the district explored. Average thickness of the whole stratum twenty-five feet.

NO. XVII. COAL—PITTSBURG SEAM.

Resting on the great limestone bed, we find the important coal seam, from which the city of Pittsburg and its environs are supplied with this indispensable mineral, and which may, therefore, by way of distinction, be entitled the Pittsburg seam. It is probably the most important and extensively accessible seam of coal in our western coal measures. The examinations of the season have shown that it spreads uninterruptedly over the whole valley of the Monongahela, from the base of the Chesnut ridge to the western boundary of the State, if not to the Ohio river. The critical investigation of

this bed and its accompanying ores, is highly interesting, and leads to some curious and striking geological inferences. The uniform disposition of vegetable matter over so extensive a tract of ocean, is in itself a geological fact, richly worthy of consideration, by any intelligent mind, while the regularity with which it maintains its characteristic features, is not less remarkable, or less likely to inspire us with curiosity to know more of the mighty operations of nature, during the earlier conditions of the earth's ever changing surface.

It consists of three parts, first the main breast of coal, and above this a layer of clay, and over this again a bed of coal, forming the roof. The former of these rests upon the limestone, from which it is separated generally by a few inches of blue clay or decomposed shale. It is from five and a half to eight feet in thickness, affording coal of the purest and best kind. In the neighborhood of Pittsburg, the lower part of this mass for about one foot in depth, abounds in thin seams of pyritous shale, and is hence rejected by the miners. Above this part of the seam, there is the stratum of blue or black clay-shale, dividing it from the coal roof. It is hard and compact when first dug out, but on exposure to the atmosphere crumbles down into a soft clay. It is generally free from gritty particles and with a similar layer in the coal next the roof, it has been advantageously used in the manufacture of fine bricks. Above it is the roof coal, consisting of a bed of coal with shale intermixed in numerous thin layers. Towards the bottom this is a band of true coal from one to two feet thick; the higher layers are generally thin. The coal in this part of the seam, is in itself of good quality, but the expense of separating it from the accompanying slate is generally too great to justify the attempt. Hence the miners along the Monongahela, content themselves with extracting the lower division, leaving the remainder to form the roof of their drifts. In Allegheny county the main breast varies from five to six feet in thickness, but as we ascend the Monongahela and approach near the Chesnut ridge, it enlarges much, yielding in some places from eight to nine and a half feet of pure and compact coal. The quantity of pyrites in the clay and shale accompanying the coal, is very considerable; these layers readily crumble, and when exposed to the atmosphere are generally covered with *copperas*, produced by the chemical action upon the sulphuret of iron. These natural incrustations of copperas are very common throughout the district. In many instances, the coal of the roof has been precipitated by a slipping of the hill side upon the lower

part of the seam, in which case the latter has often taken fire from the heat evolved by the chemical decomposition just mentioned.— This has occurred particularly at the mouth of the Redstone creek, in Fayette county, where the overlying shale, has been baked and reddened by the combustion. The shale and clay of the upper part of the seam, abound in casts and impressions of plants, many of which are very beautiful.

In tracing this seam of coal, it was an object from the commencement, to ascertain the dip and range of so important a deposite, but we were soon made aware, that this could only be accomplished by a series of accurate measurements of the height of the coal itself, and the adjacent strata at different points throughout the country.— From the peculiar character of the region, a knowledge of the dip is of little use for this purpose, being generally affected, if not produced by the manner in which the incumbent strata have been cut through at the time of the original denudation of the country. The measurements which were made for this purpose were merely experimental, and their completion may be more properly left to a later stage of the survey. Enough was developed to render it highly probable that this bed observes a nearly horizontal position, dipping very slightly to the south-west, with undulations running through it, from north-east to south-west parallel to the axis of the Chesnut ridge, and affording a miniature representation of what has taken place on a larger scale along the south-eastern side of the whole coal field, near the Allegheny mountain. Over the most considerable of the lines of elevation, the only one which has yet been minutely examined, the upper beds of coal have been swept away, and the inferior strata exposed. The anticlinal axis alluded to, runs parallel to the western base of the Chesnut ridge, keeping usually within about seven miles of it. It may be seen about four miles west of Greensburg, Westmoreland county; passing thence south-west, it may be detected a few miles west of Mount Pleasant and Connellsville; three miles west of Uniontown, Fayette county, and in the vicinity of Mount Morris, Greene county. East of this line a few miles, the coal resumes its western dip, and is found regularly cropping out along the base of the Chesnut ridge, particularly near Uniontown, Connellsville, Mount Pleasant and Youngmanstown. Its northern outcrop is believed to be about five miles north of Pittsburg, passing through the northern parts of Westmoreland county, and that part of Beaver which lies south of the Ohio river. As we approach the Kiskiminetas, the coal is found

on the summit of the highest hills, and the lower members of the series begin there to make their appearance. Whether the Pittsburg coal seam extends north of the Kiskiminetas is not known, as no examinations have yet been made in that district. Its extension in that direction is not, however, probable, for the coal seams at Saltsburg, Leechburg and other places on the river, belong to the strata below the Pittsburg series.

A more full account of this inexhaustible bed will appear in my final detailed report, where all its Geological relations and its depth below the surface of the country, at almost every point as ascertained by measurement and calculation, can be exhibited by the aid of drawings and Geological maps.

NO. XVIII. SHALE.

Reposing directly upon the coal seam, we observe a bed of shale passing generally, but not always into the overlying sandstone. The line separating it and the roof-coal is usually well defined. In the neighborhood of Pittsburg, where it forms in connexion with the next member of the series—the summits of the hills, we find it a brown friable and compact shale of a ferruginous appearance. In common with other strata, it is composed of a mixture of sand and clay, the shale enclosing sandstone layers of greater or less thickness, which increasing as we ascend, in number and size, pass gradually into a compact sandstone. In the northern part of the district, this stratum is remarkable for the quantity of mica that it contains, which causes the sandstone layers to split into large slabs, with a glittering micaceous surface and imparts to them at the same time a crumbling texture. In other situations it abounds in vegetable impressions, apparently the stems of arundinaceous plants, &c. Very frequently, particularly in the lower part, it is a very soft brown and black shale, readily disintegrating and has a splintery fracture, breaking off in long, thin prismatic fragments like the splinters of decaying wood. The surface is often covered with an efflorescence, a part of which is copperas. There are two varieties of this encrusting matter, the first, a salt of a pure white color in delicate crystals, and a greenish yellow mass, into which the former passes, by longer exposure to the atmosphere.

In Fayette county, it contains a thick bed of compact, distinctly laminated black shale, resembling in the harder parts, a roof-

ing slate ; the other layers are very soft and black. This includes a layer of coal one foot thick. Similar bands, from one to several inches in thickness, are often observed running irregularly through it. Iron ore in small quantity is not rare in it, either dispersed in irregular nodules or in thin layers. The most considerable deposit of this kind, hitherto observed, is in Connellsville township, Fayette county, where it imbeds two layers of argillaceous ore, the uppermost a band of blue nodules, each from one to two feet broad and four inches thick. The whole stratum varies much in its dimensions, being in some places very thick, and in others only from five to ten feet. It may, however, be estimated at thirty feet average thickness.

No. XIX. SANDSTONE.

At various places along the Monongahela, for example : in the vicinity of Brownsville, and higher up the river, we behold a heavy bed of sandstone resting on the preceding. It is in general, a grey slaty sandstone, alternating with layers of brown and black shale. It varies much in compactness and thickness. Frequently it can be observed from a great distance forming white ledges along the hill sides and the banks of the larger streams. In the southern part of the district we find it in its greatest development, being there frequently quarried as a building stone. Quarries of this rock are opened at Williamsport, on the Monongahela, and at several other points. Some layers of the stratum afford a fine stone of a light gray and yellow color, but of variable texture. Others are full of ferruginous concretions which render these bands difficult to dress. Carbonized remains of the ancient vegetation of the coal are not uncommon in this stratum, but no other fossils have been observed. On the steep banks of the river and in other situations, particularly at the mouth of Ten Mile creek, and for some distance lower down the Monongahela, the sandstone appears to rest immediately upon the coal. Such appearances are not unfrequently caused by slides, which bring down the heavy sandstone shelf, over the soft and yielding beds of the intervening shale. It is not improbable, however, that No. XVIII is sometimes wanting, and that the present stratum is to be found in contact with the Piusburg coal seam. Average thickness, twenty-five feet.

No. XX. SHALE.

Directly over the sandstone there lies a stratum of yellow and brown shale, imperfectly laminated with layers of sandstone, alternating in it. One portion of this rock is sometimes a tough and hard slate of a greyish color, containing grains of pure quartz.—When soft, it is frequently pressed down upon the underlying sandstone, whose cavities and fractures it fills in a singular manner with a mass of ferruginous clay, shale, and sometimes impure coal. No part of this stratum seems fit for building purposes. Thickness, twenty feet.

No. XXI. THE GREAT LIMESTONE DEPOSITE.

This is the most extensive and valuable calcareous deposite in the valley of the Monongahela or any where else in the western counties of the State, for the limestone beneath the Pittsburg coal is comparatively thin and of little importance as a source of lime for masonry or agriculture. This ample stratum, however, affords an inexhaustible supply wherever it is exposed in any part of the district. From the vicinity of Pittsburg to the southern State line, and from Chesnut ridge to the Ohio river, it may be traced continuously, either on the summits of the hills, or what is more frequent, forming shelves or natural pavements along the beds of the smaller streams. It is a non-fossiliferous deposite, no fossils having been hitherto found imbedded in it, notwithstanding the frequency with which it has been examined in tracing its range through the country. The variation in the thickness and particularly in the composition of this stratum is remarkable. It consists of numerous beds of limestone separated by thin seams of shale. These beds are sometimes in contact, at others they include thin layers of shale from one to eight feet in thickness. Instead, however, of these partings of shale, we occasionally meet with dividing bands consisting of a sandstone which is calcareous, effervescing slightly with acids, and passing sometimes insensibly into the limestone. The limestone itself, is generally of a blue color of various shades, is excessively hard and breaks with a semi-conchoidal fracture. At other times the layers are black or light yellow, and contain transparent specks of crystallized carbonate of lime. The latter variety is frequently very beautiful, and apparently hard enough and fine enough in texture to receive a good polish. If so, it would

make a handsome ornamental marble, although the thinness of the layers would interfere with its extensive use for architectural purposes. The black kind is very hard, of a slaty structure, and gives out a spotted or bituminous odour when bruised or struck. This kind is generally found in contact with the interposed black shale. In some instances it passes insensibly into it, when the shale becomes a black calcareous slate, splitting readily into smooth plates and effervescing freely when touched with an acid. Most generally the shale is very soft, of a deep blue or yellow color, imperfectly laminated, and decomposing readily into a soft clay. Not unfrequently, it contains layers of calcareous nodules. Occasionally, it is very soft and black, resembling the outcrop of a coal seam. In the southern part of the district, instead of shale, we find two thin layers of *coal* separating the limestone beds. The largest of these is two and a half feet thick, and has been opened in several places as a *coal* seam. Over what extent of country it will prove to be continuous, must be determined by future observations. The coal is of a good quality, very hard, breaks into lamellar fragments, and is separated from the layers of hard limestone by only a few inches of black slate. This band of coal has the appearance of being compressed by the limestone. By way of distinguishing it, we may entitle it the limestone coal seam. The other band embraced by the limestone, is about one foot thick. It is probable that several thin seams of coal of a few inches in thickness would be observed in this stratum, if the crumbling nature of the dividing shale did not tend to conceal them. In these shaly partings we sometimes meet with layers of limestone, in nodules of a large size and regular form, as if in these portions of the deposit, there had not entered quite enough of calcareous matter to produce a continuous bed of limestone. The consideration of these appearances, would, if we had space for the discussion, throw some curious light on the original formation of this important stratum.

This well characterized member of the series is readily recognized, and is very generally exposed in the ravines and hill sides, but being a rather variable mass as regards its minuter features, it is by no means easy to ascertain in every case, its precise composition. The quarries established in it, are generally mere strippings of the upper layers. Such is the case with those in Wilkins and Monongahela townships, Allegheny county, where the rock seems to thin off towards its northern outcrop. An idea of the manner in which it varies, may be obtained from the following sections :

Section taken at Brown's run, near Germantown, Fayette county.

1. Hard blue limestone in layers,	18 feet.
2. Blue and black shale, "	15
3. Limestone and calcareous shale,	5
4. Coal, 2½ feet with one foot of black slate beneath,	3½
5. Hard blue limestone,	5
6. Sandstone in layers,	10
7. Slate, upper part soft, lower black and laminated,	3
8. Hard blue limestone in layers,	6
Whole thickness 65½ feet,	<u>65½</u>

Section measured at the south branch of Ten Mile creek, near Jefferson, in Greene county.

1. Limestone in layers,	12 feet.
2. Shale, soft and blue, full of calcareous nodules,	4
3. Grey sandstone layers,	1
4. Limestone in layers,	7
5. Calcareous sandstone, passing into the limestone,	7
6. Blue limestone in layers,	20
Thickness, 51 feet,	<u>51</u>

Section at Brownsville, in Fayette county.

1. Limestone, hard, in layers,	25 feet by estimation.
2. Shale, black,	5
3. Sandstone, slaty,	18
4. Black calcareous slate, regularly laminated,	8
5. Limestone, slaty,	6
6. Hard blue limestone,	10
Thickness, 72 feet.	<u>72</u>

It is not, however, in every part of the district, that this deposit attains this full developement. In Allegheny, and the northern part of Westmoreland county, it is met with, covering the highest hills

with its lower layers. These are sometimes seen capping the insulated summits of the hills, and forming a natural pavement, completely detached from the surrounding strata. Advancing towards the south, we find it gradually sinking under the hill tops, and showing itself lower down on the sides of the creeks and small streams, and becoming at the same time thicker.

Along the western base of the Chesnut ridge, this stratum rises to the surface, with a gentle inclination, in company with the other members of the series, being well exposed on the Loyalhanna and Youghiogeny rivers.

Appearing as it does on the Ohio river, at Wheeling, it is not improbable that this is the same bed of limestone described by Dr. Heildreth, as No. XXIV, in the first annual report of the Geological survey of Ohio. This description applies to it very exactly.

There are but few of the streams or even small runs emptying into the Monongahela, from Elizabethtown to the Virginia line, along which this stratum is not well exposed, its beds either forming a series of horizontal steps or platforms in the smaller water courses, or steep and smooth escarpments on the hill sides. On its almost incalculable value to the agriculture of our south-western counties, I need not dwell, but I cannot refrain expressing a sincere regret that the importance of lime as a fertilizer, should continue to be so much overlooked. It is proper in this place to observe that the shales between the limestone beds themselves, are frequently very calcareous, and are consequently, in many cases, a genuine *mark*, both as respects their composition and their agency upon the soil.

No. XXII. SHALE.

Resting on the upper part of the preceding limestone, there usually occurs a thin, but well marked bed of shale, of varying thickness. The predominant colors are blue and yellow, and it is soft and imperfectly laminated. A bed of coal one foot thick has been detected in it, but this is not continuous. Thickness ten feet.

No. XXIII. FLAGGY SANDSTONE.

The next rock in order is an important bed of sandstone distinguished by its slaty and thinly laminated structure, in consequence of which it affords an abundant supply of beautiful flagstone. It is well

exposed at the town of Brownsville. The flags are obtained by splitting the rock with wedges, and can be procured of any size from the thickness of one-fourth of an inch to one foot or more. It owes its slaty structure and ready cleavage to the abundance of mica distributed in thin sheets through it. It is generally fine-grained and of a light grey color. Good flagstones are obtained from it at Brownsville and other places. The flaggy structure being owing to the accidental presence of mica—when this ingredient is wanting or deficient in quantity, the rock then becomes a compact sandstone, and the lower part is sometimes quarried as a building stone. Vegetable impressions abound in it in some localities. Its general thickness is about fifteen feet.

No. XXIV. SHALE.

Over the above we find a bed of shale, generally of a brown or yellow color, and often containing vegetable impressions. This stratum has not every where been recognized; the overlying limestone next to be described, sometimes resting on the preceding sandstone.

No. XXV. UPPER LIMESTONE.

This is a deposit of limestone, similar in character to the great deposit, No. XXI, but of less thickness and greater uniformity of composition. It consists of five or more layers of hard blue limestone, separated by a parting of shale, which is generally four feet thick, and which contains calcareous nodules and in one instance a layer of coal about one foot in thickness. Thickness of the whole mass about eight feet.

No. XXVI. SANDSTONE AND SHALE.

We come next to a very important but variable bed of sandstone and shale. In Greene county it is a solid bed of sandstone, of a light grey color, and is generally coarse-grained. In other parts of the district the sandstone is in thin layers, from one inch to two feet in thickness, separated by soft yellow and brown seams of shale.—When the arenaceous layers are abundant, the stratum is a true sandstone, but when deficient, it passes into a bed of shale, the change depending upon the greater or less quantity of sandy particles present in the mass.

There is some reason to believe that this stratum contains a seam of coal three feet in thickness, which may probably be the one seen at Brownsville, at Limetown and at Elizabethtown, and which occurs at various points upon the hills in the northern part of Washington county. The precise situation of this seam we have not yet been able satisfactorily to determine, nor has it been possible, indeed, to ascertain whether it is not identical with the limestone coal seam just mentioned. This stratum is very little exposed, in many places the shale being easily buried by the fallen materials of the hill sides. In the eastern part of Greene county, this coal is not seen; there the stratum is a thick bed of alternating sandstone and shale, and is well exposed beneath the upper coal seam, to be mentioned presently. Owing to its occurring frequently in regularly divided layers, from a few inches to many feet in thickness, it can be obtained in handsome flags, which are of a light grey color, are slightly micaceous and easily worked. Thickness thirty-five feet.

No. XXVII. SHALE.

This underlies generally the upper coal seam to be next alluded to, but sometimes it is very thin or even entirely wanting. It is a soft yellow shale, full of calcareous concretions, and the upper part adjacent to the coal is frequently converted by the weather into a soft blue clay. Thickness five feet.

No. XXVIII. COAL.

We have now arrived at a seam of coal, that for importance ranks next to the Pittsburg seam, every where throughout the southern part of the valley of the Monongahela. Although affording generally a coal of very excellent quality, it is not worked except in Greene county and the adjacent parts of Washington county. Over the northern portion of the district it has been removed from the surface by denudation. It is about six feet thick and rests on the preceding shale, or, where that is absent, on the underlying sandstone. It is divided near its centre by a band of soft shale, which varies much in thickness. The lower part of the seam affords the best coal, and with care in extracting the slate, it forms an excellent fuel; the upper part is less pure, and has a slaty structure breaking into pieces of a prismatic shape. The adjacent slate is very full of pyrites, frequently containing large nodules of that mineral, by the decomposi-

tion of which copperas is abundantly produced, forming a coating on the surface of the coal and the included shale.

This seam of coal is met with in the high hills in the neighborhood of Brownsville, and also about two miles east of Waynesburg, in Greene county. Here it is seen in the bed of south Ten Mile creek, emerging from beneath the elevated ridge of country which extends through the centre of that county, and forms the high land which separates the tributaries of the Ohio river from those creeks which empty into the Monongahela. Passing beneath this table land it is again met with, as it re-appears on the western side of the county along the south fork of Wheeling creek, a few miles from the State line. From the vicinity of Waynesburg, it spreads through the eastern part of Greene county, where it is worked extensively in Jefferson and Cumberland townships. This bed of coal will, when the country becomes more thickly settled and better cleared, be considered a highly valuable deposit, and will then be found to have a much wider range than is now attributed to it.

No. XXIX. SHALE.

Overlying the previous coal seam, we notice a bed of brown and yellow shale. It is of great thickness and seems to have been compressed by the superincumbent sandstone. On the south branch of Ten Mile creek, it in some places becomes very thin, though even there it is a well marked stratum. Generally, it is covered with an incrustation of impure copperas, and small quantities of iron ore are sometimes enclosed in it. It is often but two feet thick, separating the coal at its outcrop from the overlying sandstone. Average thickness ten feet.

No. XXX. COARSE BROWN SANDSTONE.

This is the largest bed of sandstone belonging to the upper part of the series. It is met with at Brownsville, in the high hills on both sides of the river, and extends thence through Fayette and Greene counties to the State line. This stratum is best developed in Greene county, where it extends from Waynesburg eastward to the river, capping the highest hills in the neighborhood. At Brownsville, where it has been quarried, it occurs as a coarse brown sandstone of a singular aspect, varying much in texture and composed of minute water-worn grains of white quartz. Two varieties of the rock may be dis-

tinguished, the first has a brown color, consists of large grains held together without any apparent cement, and on exposure to the atmosphere, crumbles rapidly into a coarse sand of a sharp grit. The other variety has a finer grain, is of a grey color, and would make a good building stone.

In Jefferson and Franklin townships, Greene county, where this member of the series is well exposed, it forms a thick and massive stratum. In some places it is a soft slaty sandstone, externally of a yellowish color, but in other situations its texture is coarse and the prevailing color a dark brown. Large blocks of it are frequently strewn over the hills. Occasionally it graduates into the underlying shale, but in general its inferior surface is well defined, it being a very compact and heavy rock.

This stratum in the northern parts of its range, has been stripped off from the surface by the action of the retreating waters. On the high hills adjacent to Hillsborough, in Washington county, rounded boulders of a coarse sandstone are found, which have evidently been derived from this stratum; in like manner in Menallan and Redstone townships, in Fayette county, similar blocks are found, scattered in large fragments over the tops of the highest hills. Average thickness thirty-five feet.

OF THE STRATA ABOVE THE PITTSBURG SERIES.

It is believed that no part of the district contains rocks superior in their order of stratification to those just described, if we except the narrow belt of country a few miles in width, which forms the dividing land between the Ohio and Monongahela rivers, and which extends from the town of Washington southward, through Greene county to Dunkard's creek, on the Virginia line. The hills here are generally high, and not well cleared, affording few exposures adapted to minute Geological examinations.

So far as they have yet been investigated, these upper strata consist of thin beds of shale, sandstone and limestone, imbedding no deposits of much value, excepting iron ore, which there is reason to believe exists in some of the upper shales. When engaged in this portion of our exploration, the season was too far advanced to enable us to make any very satisfactory examinations. I may, however, subjoin the following section, the only particular enumeration of the strata above No. XXX, that we have been able to construct from ac-

tual observations and measurement. It is of course imperfect, but will be rendered complete in the detailed investigation, which this district will require hereafter.

SECT. 31. Shale, blue and friable,	7 feet.
32. Coal, 20 inches; this is worked in several places.	
33. Shale, blue, with calcareous nodules,	3
34. Limestone in layers,	4
35. Shale, soft, blue and badly laminated,	4
36. Limestone in three layers,	4
37. Shale, blue and yellow,	10
38. Sandstone, very slaty, splitting into thin layers,	20
39. Shale, brown and blue,	10
40. Coal,	1
41. Shale, brown and blue,	4
42. Sandstone,	20

This section is the result of observations made in Waynesburg, in Greene county.

OF THE COUNTIES NORTH OF THE OHIO RIVER.

Transferring our attention in the next place, to that region of the State which lies north of the Ohio and west of the Allegheny rivers, let us enter upon a brief enumeration of the strata, as developed in this north-western portion of the basin.

The lateness of the period in the summer, when the explorations in this district were begun, owing to the unavoidable delay in procuring the services of a competent assistant, combined with the extent of country which it was necessary we should traverse, in the way of reconnoissance, preliminary to a systematic and detailed survey, besides certain impediments, incident to the examination itself, arising out of some local irregularities in the stratification, have all conspired to prevent our arriving at as complete a knowledge of the range and relative positions of the rocks and their imbedded mineral deposits, as we obtained in the more easily explored region of the valley of the Monongahela. Nevertheless, I am enabled to present such a sketch of the Geology of this portion of the basin, as will show the nature and situation of its mineral resources, and convey a general idea of the progress already made in the exploration; which, in reference to the State at large, is indeed the principal objects of my annual reports. In a section of the State where the investigation

may be said to have been only commenced, there are many local facts and numerous and minute measurements already recorded, which are necessarily too incomplete to make it proper to refer to them at present. They are reserved in order to incorporate them with fresh details to be hereafter collected, when their utility and their important practical bearings, (now liable, possibly, to misinterpretation by those who are unacquainted with the proper mode of tracing the mineral deposits of an extensive region,) will justify any present delay in submitting them to the public.

STRATA OF THE NORTH-WESTERN PART OF THE STATE, WHICH LIE BELOW THE COAL MEASURES.

For reasons already stated, these will claim, at present, only a passing notice. Adopting as a convenient Geological boundary, the escarpment facing the north-west, or, in other words, the north-western slope of the line of hills, which stretches from near the State line, north of Warren, south-westward by Meadville, to the neighborhood of Sharon, we shall find the country included between that limit and Lake Erie, embracing chiefly Erie county and part of Crawford, to consist of strata of our formations VIII, XI, and X, but principally of those of formation VIII. Minute research may possibly enable us to detect hereafter, in the thin seam of arenaceous limestone found near the base of these hills, at Meadville, evidence of its being the final thinning away of formation XI, already described, as exposed along the south-eastern side of the basin on the flank of Chesnut ridge. The line of hills above traced, marks the extreme north-western margin of our great bituminous coal field, being capped by the conglomerate of formation XII, generally the immediate substratum of the coal measures. The inferior destructibility of this rock, compared with the softer ones between it and the lake, by causing a less degree of denudation of its surface by the retreating waters, is the reason of its forming the edge of the table land upon which all the coal reposes, in a very gentle inclination to the south or south-east.

The easily decomposed shales and argillaceous sandstones of formation VIII, have furnished much fertile soil to parts of Erie, Crawford, and the adjoining counties. Thin bands of more or less pure limestone, occasionally imbedded in this formation, deserve to be especially examined, in order to learn their true range and position,

and to detect any possible connection they may have with the valuable deposits of calcareous *marl*, so abundant in some of the low grounds of this region, Pymatuning and Conneaut swamps for example. An attention to whatever may bring to light, in these localities, the existence of so useful a fertilizing material, must be important to the practical objects of the survey, and will influence, in part, our future researches in this region.

Approaching the base of the chain of hills, capped by formation XII, we meet with slates occupying a rather higher place in the series, which, judging from many of their external features, seem to be referable to formation IX, and a portion of them, probably to formation X. There is a difficulty in defining, at least at present, the respective limits of these three formations, or indeed in establishing unequivocally the separate existence of the two last. In truth, strong doubts may be started, whether the alternation everywhere more or less observable between formations VIII and XI, and also IX and X, may not comprise, in the part of the State now before us, nearly the entire mass of this portion of the series, implying a more intimate blending of the several materials, as they reached this part of the bed of the ancient sea, than took place in districts more to the south-east, where they have been separately super-imposed.

A reference to the stratification, as we behold it in the vicinity of Meadville, will tend to convey a tolerably exact conception of the nature of the beds of rock which occupy the four hundred feet of depth below the base of the conglomerate stratum, (formation XII,) which there caps the hills, forming part of the general margin of the coal field.

These hills, on the north and south of the town, are at their greatest elevation, four hundred and eighty-eight feet above the bottom of the canal, and expose the upper strata especially, with some degree of distinctness. The lower ones are not so continuously exhibited to view, making it more difficult to determine their true order of succession.

Near the level of the canal, the beds are of brown slate and sandstone, and over this we find a thin bed of clayey shale, then the sandstone repeated, and then another layer of red and grey shale, two or three feet thick. Near the outcrop of this bed of clayey shale, a spring issues near its upper surface, encrusting all the rocks beneath it with a coating of carbonate of lime. At a higher level are seen thin

beds of calcareous shale, some of which abound in fossil shells and other organic remains. From this shale to the height of one hundred and fifty feet, occur alternations of coarse, brown sandstone, and thinly laminated bluish slates, and flaggy olive sandstones and olive slates. At that height we meet a bed of blue shale four feet thick, and over it brown sandstone and olive slate, until we reach two hundred and thirty-five feet. Here we encounter a bed of *sandy limestone* two feet in thickness, which, as it is a peculiar rock, and remarkably continuous for so small a stratum, deserves particular notice. It is compact and exceedingly hard, containing a large though variable proportion of siliceous or sandy matter. It lies in large and nearly square masses, the angles of which are more or less rounded off, owing to the readiness with which the lime is dissolved out of the rock. By the removal of this ingredient, and the oxidation of the iron in the stratum, it acquires a brown siliceous crust, sometimes thick, indicating, it is to be feared, too large a proportion of sandy matter to qualify this rock to be converted into even an impure lime. In an attempt once made, the excess of sand in the rock, produced with the lime a slag. In such cases a more moderate degree of heat will sometimes prove more successful. Under the limestone, in a massive bluish sandstone, we find thin layers of an impure *iron ore*.

Ascending from the limestone, we pass thick beds of brown and bluish sandstone, some of which latter are slightly calcareous, thin beds of fossiliferous and calcareous slate, succeeded by others of brown and blue shale.

At the height of four hundred and twelve feet, we arrive at the base of the great bed of conglomerate, consisting of sand and of siliceous pebbles, never larger than a common marble or a large pea. The same rock is seen at the height of four hundred and fifty feet. Its soil is different from that of the rocks beneath it, being said to be better fitted for wheat, and sustaining a luxuriant growth of chestnut trees.

The hill to the south of the town has a less elevation than that to the north, by nearly fifty feet; but as the soil here contains scattered fragments of coal, a fruitless search was once attempted for coal, which a moderately shallow boring would have shown could not exist.

On French creek, seven miles south-east of Meadville, the conglomerate caps the hills, which are there very high.

Of the general face of the country, on the north-western side of the coal field, it may be instructive to make some mention in this place, as tending to assist in forming a correct notion of the position occupied by the coal and other mineral resources in this quarter of the State. In the western part of Mercer and Crawford counties, the table land supporting the coal measures, is intersected by long, straight and rather wide valleys of denudation, leaving the upper shale, containing the coal, in long parallel intervening ridges, which range in a north by west and a south by east direction. The largest streams pursue the valleys, merely crossing through the ridges out of one valley into the next, but the small tributaries rising in the hills, find their way transversely down their flanks by ravines, into the main valleys. From the Ohio river northward, the general plane of the country gradually rises, but with a very gentle inclination. From the mouth of the Beaver to the surface of Conneaut lake, the ascent is only four hundred and eighteen feet. The tops of the highest hills near New Brighton, are about five hundred feet above the Beaver, at its mouth. At the bend of the Shenango, where the canal is two hundred and forty-one feet above the mouth of the Beaver, the hills rise three hundred and ninety-five feet more, making six hundred and thirty-six feet above the mouth of Beaver creek; and Pymatuning ridge, in Mercer, is about fifty feet higher than these. At Meadville, the canal is four hundred and twenty-three feet, and the hills nine hundred and thirteen feet above the former point, the mouth of Beaver. We perceive, therefore, that the actual ascent of the plane, including the summits of the hills, from the Ohio river to the margin of the coal basin, hardly exceeds four hundred feet. Nevertheless, gentle as this rise in the land towards the north appears, it has the effect of spreading out the valuable beds of coal, iron ore and other materials in that direction, over a much wider space than they would have covered, had the surface of the district been entirely horizontal. After thus supporting the lower strata of the coal measures, this gently inclined plane sinks suddenly to the lower plane or terrace which borders, in a broad belt, the southern shore of Lake Erie, the surface of which is only eighty feet lower than that of the Ohio, at the mouth of the Beaver. Throughout almost the entire extent of this upper plane, the lowest bed of coal, with its accompanying iron ores, still clings to the surface, and though discovered in few places, will ere long, it is believed, be developed at many points, where its existence is not now suspected.

Along the line of the canal, from the Conneaut lake to Sharon, the coal already found in many places, will be traced and ultimately opened in a multitude of localities; for the lines of levelling which have been executed, show that the coal rises but little more rapidly to the north than the surface of the country itself. One valuable locality where it can be readily mined, and from which it might be conveyed away by the canal with great facility, would be the Bend hill, on the Shenango. Although the coal has not yet been discovered at this point, the measurements and observations made tend to give considerable confidence in its being soon found there, if the excavations be judiciously conducted.

The subjoined estimate is presented for the sake of showing the advantages to this section of the State, which may be anticipated from an early development of its coal beds, which, situated on the northern margin of our coal field, have open to them, so soon as the Shenango shall be finished, the boundless market of the region of the lakes.

Expenses of mining and transporting the coal from the Shenango to Erie and Buffalo.

At the mouth of the mine the coal will here cost, per bushel,	1½ cts.
Cost of delivering it from there into the boats,	1
Transportation to Erie, including lockage,	6
	—
Whole cost delivered in Erie, per bushel,	8½
	==

The present market price of coal, in Erie, is twenty-five cents.

To convey it on to Buffalo, would swell the expense about two cents more per bushel.

Sharon, the neighborhood of Clarkesville, and of Greenville, and other places similarly well situated with these and the Bend hill, will supply the northern market with coal, under circumstances of cost at once highly advantageous to our own citizens, and to the consumers to whom this excellent fuel is becoming daily more indispensable.

At a point about eight miles west-south-west of Meadville, and three miles south of Conneaut Lake, coal is found, and the conglomerate, (called in this part of the State, the "Pebbly rock,") occurs exposed about three-fourths of a mile to the southward. Upon level-

ling the surface between these places, the bottom of the coal was ascertained to be level with the top of the conglomerate, but the real direction and the extent of the trivial dip in this place has not yet been determined.

The coal which lies near the surface, has been opened only recently, and of course near the outcrop it is somewhat broken. It is, however, of excellent quality, especially for the use of the blacksmith, being of a bright lustre and pure. The bed measures from three and a half to five feet in thickness. This coal sells at Meadville for seventeen cents per bushel.

About one hundred feet below the conglomerate in this vicinity, a bed of blue shale contains many seams of an impure variety of iron ore of the kidney form. A bed of arenaceous limestone, closely resembling that at Meadville, occupies at this place, the same relative position to the overlying conglomerate which it has there, being about two hundred feet above it. The sandstone overlying it, is also very similar, though it abounds more in the fossil vegetable impressions, called *fucoides*. In this neighborhood there are many high hills, which promise an abundance of coal, though the inhabitants have never, until now, suspected its existence. The natural exposures are not good, and a very critical examination made by the aid of instruments will be requisite before its exact position can be ascertained.

Iron ore has been found near the coal, and below the conglomerate. Travelling towards the south and south-east, the conglomerate and coal gradually descend in height to the level of the lower hills. Three miles south-west of Greenville, coal is found at Yockstemer's, two hundred and forty feet above the bottom of the canal, from which it is distant a mile and a half to the westward of it. It here lies very irregularly, showing a difference of level of seven feet in the space of a few rods. It is about three feet thick, and of the variety called *slaty cannel coal*. At this point the conglomerate lies above the coal now spoken of, separated from it by from twenty to twenty-five feet of argillaceous strata.

At Georgetown, the conglomerate, coal and iron ore, are all found a little below the highest summits of the vicinity. The coal is about three feet thick, of a dull black, and in structure and aspect, is a *slaty cannel coal*. Iron ore in great abundance has been thrown out in excavating the drift at the mouth of the coal mine.

Above the coal to the height of about twelve feet, the hill side abounds in fragments of a bluish conglomerate, containing the usual white pebbles, but the adjoining sandstone is more sparsely studded with them. In many places in the neighborhood of Georgetown, the conglomerate, well marked in all its characters, is seen overlying the coal. Between them, there usually lies a shale containing several seams of excellent iron ore. Two in particular, which are separated by only a foot of shale, measure in aggregate thickness, twelve inches, the upper one seven inches, the lower, which is of a beautiful blue color and fine texture, five inches.

A small furnace is now erecting to smelt the ore, (a mile or more, however, from the spot where the foregoing measurements were made.)

It is of a rather novel design. The blast is to be propelled by a steam engine, in which the steam will be generated by the heat supplied from the stack of the furnace, to which the boiler is to be attached. It is a small quarter stack furnace, and is, strange to say, with one exception, the only furnace in Mercer county.

Along the margins of several runs which enter the Little Neshanock, our explorations brought to light a bed of arenaceous limestone, exactly corresponding in its position and quality to the seam already alluded to, as occurring at Meadville and Conneaut lake.—Not far below it, my assistant, Mr. Hodge, found at Mr. Milnor's, where the township line crosses the Little Neshanock, a bed of blue shale from ten to fifteen feet thick, containing *eleven* layers of iron ore of pretty good quality. The aggregate thickness of the ore was estimated at a foot and a half. The shale appears to be adapted to making a good fire brick.

This neighborhood seems to possess claims as an iron manufacturing district, not only from the abundant supply of good ore in it, but from its capacity to furnish a competent quantity of charcoal, much of the land being still covered with an exceedingly heavy growth of hard wood. Bog iron ore has been found in considerable amount, but its purity is somewhat problematical.

Approaching the town of Mercer, on the turnpike, we soon encounter a thick bed of sandstone, which is of various colors, or red and mottled in its upper portions. It is full of thin streaks of iron ore, which impart to it a peculiar feature. Near its base the stratum is very white. It lies above the conglomerate, and its thickness is

at least one hundred feet. Half Moon Swamp lies below this, its level being about the position of the coal bed. This sandstone stratum passes under the town of Mercer.

A bed of slaty cannel coal like that at Georgetown, has been discovered at a place called Orangehill, in Pymatuning township.—About two hundred feet below it, we found a bed of arenaceous limestone one foot thick, one mile and three quarters from this coal.—East, nearly thirty-three degrees north, the same bed is exposed twenty-three and a third feet higher in level, giving a dip of thirteen and one-fifth feet to the mile, estimated in the direction west, thirty-three degrees south, though this may not be the direction of the maximum dip of the stratum. The land between rises to the height of one hundred and ten feet above the lower coal bed. This is also the height of Pymatuning ridge, where search has been made for the coal seam, by digging numerous shallow pits at one and a fourth miles south-east by east of the spot where it has been opened, but without success. On levelling from the coal to this spot, the conglomerate was passed lying about fifteen feet above the level of the coal.

Should the coal be found hereafter below the lowest stratum of brown shale, which is above the conglomerate, it will prove that a sensible dip, or, what is far more probable, a dislocation of the strata, occurs in the intervening distance, equivalent to a descent of forty feet to the mile, in a south-east by east direction.

SANDSTONE STRATA, AFFORDING QUARRIES ALONG THE SHENANGO.

In the neighborhood of "Big Bend," some important quarries of sandstone have been opened to supply materials for the construction of lock No. 15, and the dam near it, belonging to the Shenango navigation.

The first of the quarries is at an elevation of about one hundred feet above the canal, and one mile higher up the valley than the lock. The stone is employed in the slope wall and bridge piers. It is a firm, bluish sandstone, slightly calcareous, and lies in a solid mass, thirty feet at least in thickness. It may be quarried in blocks, whose greatest thickness is about two feet. A temporary rail road conveys the stone upon little trucks, regulated by a break. This is the most convenient quarry to the canal. The stratum extends down the

valley to Sharon, three miles above which it is quarried in another place, and it occurs at Meadville, where stone has also been extracted from it. It may be readily recognized, by its bluish tint and slightly calcareous properties. Between this rock and the conglomerate which overlies it at a considerable height, there is a massive stratum of brownish sandstone, which might be readily quarried on the Shenango, if it were thought desirable. It yields good stone two miles south-south-west from Conneaut lake.

Both these valuable strata not making their appearance at the surface near lock No. 15, the contractors not being aware that they range in nearly the same continuous plane under all the hills, have passed over them on the northern side of the Shenango, while they have gone beyond the siliceous conglomerate to establish a quarry in the thick bed of sandstone on the very summit of the hill, which is here nearly four hundred feet high. To procure some of their stone, they even go down on the *other side* of the hill to the conglomerate, simply because it was there exposed. Directly opposite, they pass over all the lower beds of sandstone unheeded, to the conglomerate; and until recently, they passed by this and continued a mile further, by an expensive road constructed expressly for the purpose, to procure their stone from the stratum of the red and variegated sandstone exposed on one of the highest summits of the Shenango hills.

On the top of the Keel ridge, four and a half miles from Sharon, the same bed of red and variegated sandstone shows itself, and is quarried to be taken thence to lock No. 6, below Sharon, a distance of at least four miles, while an inexhaustible supply of stone, certainly as fit for the purpose, might be procured in the immediate vicinity of the work from the other strata enumerated.

The above details are introduced for the purpose of impressing upon the engineers the great importance to the State, or to the companies constructing public works, of themselves exploring, somewhat in detail, the stratification in the neighborhood of their surveys, and of doing this prior to issuing their proposals to contractors.

The contractors on the works of internal improvement in the United States, are at present, a large majority of them, new in their business, and untaught in even the rudiments of practical Geology, a subject of all others, the plainer principles of which it behooves them to understand. The consciousness of this makes them uncertain of a supply, in every case of apparent difficulty, in procuring